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THESIS

THE COMPARATIVE EFFECTIVENESS OF CONVENTIONAL SCHOOL-HOUSE TRAINING VS. INTERACTIVE COURSEWARE

by

Steven L. Richter

September, 1997

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Findings from three separate analyses are presented. The data analysis provides a basis for concluding that this system may be an effective way to deliver training to members of the shipboard damage control organization in a manner in keeping with the "Smart Ship" concept. Exit level of knowledge comparisons between personnel that used the IDCTT (RPL) as an augment to the standard RPL school curriculum and those that did not are examined, and final results and recommendations are provided. Recommendations for improvement of the system, as well as further research topics are also provided.

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requirements for the degree of

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ABSTRACT

This paper reports the results of a study that compared the effectiveness of the traditional school-house and an interactive multimedia system in training Repair Party Leaders. The study was conducted over a period of three months at the Repair Party Leader School, Fleet Training Center, San Diego, California. Subjects participating in the study ranged from mid-grade enlisted sailors (second class petty officers) to junior officers (Ensign through Lieutenant Commander).

Findings from three separate analyses are presented. The data analysis provides a basis for concluding that the interactive system may be an effective way to deliver training to members of the shipboard damage control organization in a manner in keeping with the "Smart Ship" concept. Exit level of knowledge comparisons between personnel that used the IDCTT (RPL) as a supplement to the standard RPL school curriculum and those that did not are examined, and final results and recommendations are provided. Recommendations for improvement of the system, as well as further research topics are also provided.

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EXECUTIVE SUMMARY

Over the past several years, computer-based, interactive training has become an important part of the military's education system. This technology, once out of reach due to cost, is gaining acceptance within the Department of the Navy as a means of either supplementing or replacing school-based training. With the decreasing cost of Windows-based personal computers, the Navy is aggressively pursuing development and procurement of interactive courseware that will, by providing improved, "just in time" training, enhance the overall combat readiness of ships and aircraft within the force.

The IDCTT (RPL) is a U.S. Navy-developed software program that provides realistic integrated shipboard casualty control training. This system utilizes a large database and numerous video clips to provide the trainee with a very realistic training environment. The intent of IDCTT (RPL) is to provide the student with practice in collecting and processing information, coordinating responses, and maintaining the overall damage control picture. These skills are difficult to develop outside of actually imposing damage control scenarios and then evaluating the Repair Party Leader's actions and responses. IDCTT provides the RPL candidate with unlimited opportunities to "test his or her mettle" against the computer, practicing personnel and equipment management, prioritization of effort and event sequencing. This software also provides the support necessary to conduct simultaneous interactive team training. The ability to modify scenarios at the local command level enables the ship's damage control training team to tailor training to specifically target areas of weakness identified during drills or other training sessions. IDCTT (RPL) provides immediate student performance evaluation and feedback, reinforcing the training received by the user. Finally, cross-platform connectivity between Windows-, Unix- and OS2-based operating systems allows for system flexibility.

Repair Party Leaders are trained at Fleet Training Centers in San Diego, California, and Norfolk, Virginia. The course of instruction emphasizes advanced damage control theory through classroom lecture, and provides for some practical

application of topics presented in the classroom. However, the limited nature of the course, as well as restricted facilities, allow the student little opportunity to actually coordinate the activities of a Repair Locker, manage personnel and equipment, or exercise decision-making techniques. It is thought that use of IDCTT (RPL) as an educational augment at the school will enhance this opportunity, and result in an improved graduate, one more ready to contribute to his or her ship's damage control readiness.

The study was conducted using students from three RPL school classes that convened in March, April and May 1997. For this research, each student involved was given the option of not participating in the study. Of the 73 students attending the school during the three-month test period, all opted to participate in the experiment. The March and April classes were randomly divided into two groups (control and treatment), with the treatment group having their training augmented by use of the IDCTT (RPL). In April, however, the treatment group was comprised of volunteers.

For the study, the control group proceeded through the school-prescribed training track. The treatment group also passed through the normal curriculum, but was also given standard scenarios during the course requiring the use of the IDCTT. During week two of the course, each student sat before an oral board (examination). These oral boards were conducted by two retired senior Naval officers, both with command experience. The "proctors" had no knowledge of the subject's training track, ensuring an unbiased evaluation. Questions asked at this board were designed to determine level of knowledge based on standards established by the Repair Party Leader Personnel Qualification Standard.

Data analysis revealed that the students that used IDCTT (RPL) as an augment to the established curriculum performed significantly better on the oral boards than did those in the standard training track. In fact, the treatment group posted a mean oral board score of 60.78, compared with 48.47 for the control group. These figures correspond to a quantitative learning advantage of 20.26%, a value that corresponds with results from similar studies regarding the effectiveness of interactive training systems. The May class

volunteers performed even better, showing a quantitative learning advantage of 77%.

Based on the results, it can be concluded that use of IDCTT (RPL) at the Repair Party Leader School in San Diego did have a positive impact on the oral board scores recorded by the treatment group. This technology holds great promise for improving the training available to shipboard personnel. Improved training will contribute to enhanced damage control readiness, and will enable ships to meet the requirements of total ship survivability.

I. INTRODUCTION

Over the past several years, computer-based, interactive training has become an important part of the military's education system. This technology, once out of reach due to cost, is gaining acceptance within the Department of the Navy as a means of either supplementing or replacing school-based. With the decreasing cost of Windows-based personal computers, the Navy is aggressively pursuing development and procurement of interactive courseware that will, by providing improved, "just in time" training, enhance the overall combat readiness of ships and aircraft within the force.

Systems that have been developed for use by the Department of the Navy include the Interactive Damage Control Training Technology (IDCTT) for Damage Control Assistants, as well as interactive multimedia courseware used to provide challenging decision-making scenarios to junior officers in command of the CYCLONE-class PC's (coastal patrol boats). In the instance of IDCTT, the primary goal of the software is to provide a supplement to training received in the traditional schoolhouse. On the other hand, the system employed for the commanding officers of the PC's is used to expose the individual to "the worst day at sea", causing him to have to make quick and accurate decisions in order to avert catastrophe and complete an assigned mission. (J. Miller, personal communication, September 26, 1996)

The purpose of this thesis is to determine the effectiveness of the use of an interactive multimedia system in the training of Repair Party Leader (RPL) candidates in order to prepare them to assume the responsibilities associated with this position in the ship's damage control organization. This research will examine whether the use of interactive courseware to supplement training received by students at the Repair Party Leader course conducted at U.S. Navy Fleet Training Centers will result in a graduate that is closer to achieving qualification as a Repair Party Leader. It is predicted that a student that has used IDCTT (RPL) in conjunction with the Repair Party Leader Course will have a significantly higher exit level of knowledge than one trained by traditional schoolhouse methods alone.

II. BACKGROUND OF INTERACTIVE LEARNING

A. CONCEPTS OF INTERACTIVE MULTIMEDIA USED IN EDUCATION AND TRAINING

Computer-based instruction (CBI) using interactive multimedia has gained increased acceptance over the last 20 years as an effective and inexpensive means of providing training to military personnel. This method is well suited to military applications as training resources dwindle and the requirement for personnel able to operate and maintain sophisticated systems increases. As a computer-based system, IDCTT (RPL) serves as a tool with which to assist the Repair Party Leader in developing decision-making skills based on a foundation of knowledge in basic and advanced damage control.

Spiro (as cited in Seidel and Weddle, 1987) describes an "Experience-Consolidation System" as a computer-based teaching tool that assists the user in developing judgement and intuition that will result in better decision making skills. IDCTT (RPL) can be categorized as such a system in that it focuses on the user's ability to make correct decisions and instigate action in a time-compressed situation. Experience-Consolidation Systems teach what is normally associated with repetition and practice in the field by helping to establish patterns for problem solving, and causing the user to "think for himself." (Spiro, 1987)

Taylor (as cited in Alessi & Trollip, 1991) classified instructional computing into three categories: tutor, tool and tutee. The tool and tutee categories do not apply to IDCTT (RPL), and are not discussed in this research. For computer-based instruction like that presented by IDCTT (RPL), the system serves primarily as a sort of tutor. Although it does not walk the trainee through a scenario, IDCTT (RPL) provides information and assessment via end of session feedback. Additionally, during the conduct of the scenario, the user has access to several options that serve as memory aids, or prompts, that will cause the user to draw on previously obtained knowledge of damage control theory, procedures and doctrine in order to make the correct decision.

A difficulty with any computer-based instruction is that for the system to provide any positive result, the user must be comfortable with the operation of a personal computer (Alessi and Trollip, 1991). In today's military, it is likely that more recently-inducted members will have frequently used computers prior to joining, where as personnel that have been in the service for several years may never have been exposed to them. This disparity may result in differences in results obtained by users of the computer-based learning system, and may discourage those that have little or no computer literacy.

In order to maximize results, the computer should be used in training situations where it is likely to be beneficial (Alessi and Trollip, 1991). Providing training to candidates or serving Repair Party Leaders is a good application as the traditional training cost is high (i.e. the individual Sailor is absent from his ship for 12 days), and the nature of the qualification process requires many repetitions of drills. IDCTT (RPL) can provide low-cost training to individual students, reducing the impact this training has on the remainder of ship's company.

Alessi and Trollip (1991) describe instruction as a four-part process. The initial phase is that of "presenting the information." In the case of the Repair Party Leader, this is accomplished through the trainee's completion of prerequisite Personnel Qualification Standards and attainment of appropriate qualifications. Phase two of the process is that of "guiding the student." IDCTT (RPL) provides a modicum of guidance via "pull-down" menu options that can be selected by the user, as well as prompts provided by the "phone-talker" and messages from the On-Scene Leader and Damage Control Central. The third and fourth segments of the process involve "practicing the student" and "assessing learning." IDCTT (RPL) uses the concept of drills to enhance student performance, but, in the strictest sense, does not provide training for the user. Alessi and Trollip (1991, p. 108) stress that single drill sessions should not exceed 15 minutes in order to prevent user boredom or fatigue. As currently configured, IDCTT (RPL) drill scenarios require between six and 15 minutes to complete.

Computer-based drills have the ability to provide a flexible, interesting learning environment to the user. The employment of sound and video clips, as well as

sophisticated visual graphics, provides the student with a realistic presentation of situations and any impact his or her decisions may have on the progress of the scenario. This multimedia environment may stimulate further study into the concept being pursued, and, as a result, a higher level of user ability.

B. APPLICATIONS OF COMPUTER-BASED, INTERACTIVE AND MULTIMEDIA INSTRUCTION

As mentioned earlier, the Navy is in the process of fielding several computer-based training systems. The U.S. Army has also invested resources in the development of interactive training systems in an effort to more efficiently spend scarce training dollars. One such system developed by the U.S. Army Signal Center at Fort Gordon, Georgia, involves the use of interactive videodisc technology to train communications-electronics military occupational specialties. This system uses a microcomputer and laser videodisc to provide an interactive learning environment for soldiers in these fields (Winkler and Polich, 1990).

Another application of interactive training employed within the Navy involves the training of U.S. Marines in field first aid. (Dr. Eric Allely, personal communication, January 15, 1997) It is desirable that when in combat, every Marine be capable of performing life-saving measures on a wounded comrade, providing support until other field medical personnel arrive to treat the casualty. A system similar in design to IDCTT has been developed for this purpose, and field-testing indicates that it is an effective way to train Marines in this very valuable skill.

C. PREVIOUS FINDINGS

Interactive learning attempts to reduce training time required to raise an individual to a certain level of task proficiency. Studies conducted by Orlansky and String in 1979, and Orlansky, String and Chatelier in 1982 (as cited by Funaro and Lane in Seidel and Weddle, 1987) showed that in typical settings, computer-based

learning applications "achieved an effectiveness equal or slightly superior to conventional methods with a time savings on the order of 30 percent." While this research does not address the issue of time, the use of IDCTT (RPL) as a means of reducing time required to earn qualification as a Repair Party Leader is an area that provides opportunity for further study.

Unfortunately, previous studies do not indicate that computer-based instruction provides a noticeable improvement when compared with training conducted using conventional methods, except in the application of reducing time required to learn a task. In fact, many studies indicate that there is no significant difference between results achieved by interactive and conventional instruction. Clark and Craig (as cited in McKenna, 1995) found that the use of multimedia technology is not itself the factor that influences learning, and that "measured gains in studies of the instructional uses of multiple media are most likely due to instructional methods such as interactivity that can be used with a variety of single and multiple media." Alessi and Trollip (1991) report that "research aimed at proving that computer-based instruction is better than using a book, teacher, or some other traditional method has shown only a small effect in favor of computer-based instruction."

Research conducted at the Naval Postgraduate School on a system similar to IDCTT (RPL) indicated that students were receptive to the training and felt as if they had learned more. In particular, Johnson (1994) stated that, as found by a study of the IDCTT (Damage Control Assistant) system, that "the IDCTT trainer is a highly effective training aid in a shore based environment." In the same study, Johnson (1994) reports that when comparing actual performance scores obtained by students using traditional training methods with those obtained using IDCTT, "the IDCTT is clearly the more effective training medium."

D. IDCTT (RPL) SYSTEM DESCRIPTION

The IDCTT (RPL) is a U.S. Navy-developed software program that provides realistic integrated shipboard casualty control training ("IDCTT Repair Party Leader",

N86D pamphlet). This system utilizes a large database and numerous video clips to provide the trainee with a very realistic training environment. In the system's current configuration, the user is presented with an opening screen that allows him or her to select from a few scenarios, including damage resulting from a collision while underway and damage resulting from a collision while at anchor in a busy strait. All scenarios are designed around the characteristics and capabilities of the ARLEIGH BURKE-class guided missile destroyer (DDG-51). Figure 1 provides a sample view that would be presented to the user. In this view, the user (i.e. the Repair Party Leader) is able to observe messages sent by his investigators, as seen in the lower left section of the display. In Figure 1, the investigator has reported to Repair 3 that at time 1607, flooding water is four feet deep in compartment 4-370-5-A, Supply Storeroom Number 3. All messages sent and received during the IDCTT scenario are generated in the format prescribed by NWP-3-20.31, Surface Ship Survivability, ensuring continuity of training. Each time a message is received at the Repair Locker, the "New Report" pushbutton above the window flashes red, prompting the user to read the new message. By using the arrow button on the lower part of this window, the user can page through all messages,

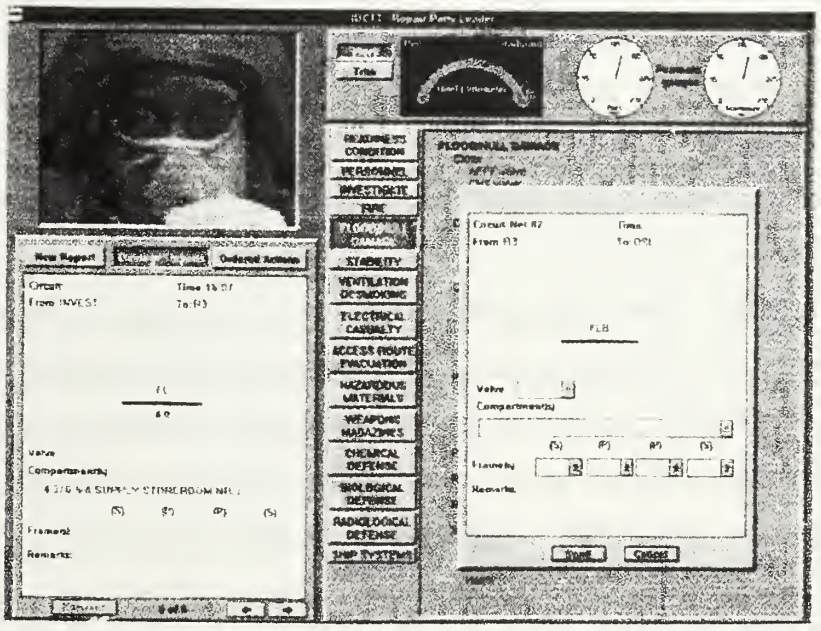

Figure 1. Sample IDCTT Display (from OPNAV N86D pamphlet).

reviewing status and progress of damage, as well as subsequent efforts to control the effects of the damage. The video clips are presented in the upper left-hand portion of the window. In the case presented in Figure 1, the Repair Party "phone talker" is (verbally) reporting the content of the message presented in the window. The "phone talker" will not report the substance of the message to the RPL until the "New Report" pushbutton is depressed, but will inform the RPL that he is in receipt of a new report. The longer the RPL waits to ask for the report, the more insistent the "phone talker" will become. This mimics the real life flow of information from the On-Scene Leader (OSL) to the Repair Party Leader, providing for enhanced realism and increased pressure for the RPL to act.

In the right-hand section of the display, the user is generating a message to the On-Scene Leader in response to the report of flooding received at 1607. In this message, the Repair Party Leader is directing the OSL to establish flooding boundaries to control the effects of the damage and prevent progressive flooding. When the message is ready for transmission to the scene, the user will have identified primary and secondary flooding boundaries both forward and aft of the affected compartment, using the "pull-down" menu keys in the window. These "pull-down" menus provide a list of frame numbers from which the RPL may select to designate as a boundary.[1] Selection of an incorrect or inappropriate frame will result in complications later in the scenario. When the message is complete, the user will transmit it using the "Send" action button at the bottom of the window. Actions previously directed by the Repair Party Leader are available for review by selecting the "Ordered Actions" pushbutton on the message dialogue window.

Other features of the display include the stability/firemain and information sections. As can be seen in Figure 1, the stability/firemain section provides visual output of one of the two available inclinometers. Currently, the RPL has selected to view the heel inclinometer, indicating the list of the ship as a result of the damage situation in progress. He or she could select trim information by using the mouse to click on the

[1] A frame is an athwartships strength member of a ship's hull, numbered from the bow aft. Frame numbers are used as reference points to locate fittings and compartments (Noel and Beach, 1977). In the design of a ship, there are special frames at regular intervals that identify the location of primary watertight and smoketight boundaries. These particular frames are the ones normally selected by the RPL at which to establish fire or flooding boundaries.

Trim action pushbutton, resulting in the display of another inclinometer.[2] This information is important to the RPL as it provides a visual indication of the ship's stability condition. The gauges on the right side of this window provide firemain pressure indications for the port and starboard loops of the DDG-51 firemain system. In the center of the display, the RPL has the option of selecting specific information regarding one of several topics. In this instance, the RPL is viewing the "Flood/Hull Damage" menu. From this menu, other actions are available including valve isolation, establishment of boundaries and dewatering options. Each menu presents a list of options for the RPL based on the general title of the section. When the user selects a subtopic, a window "pops up," allowing the RPL the option of directing the OSL to take some action. The flooding boundary establishment window displayed in Figure 1 provides an example of what the RPL will see when a subtopic is selected. If he were interested in undertaking dewatering of the affected space, the RPL would be, for example, offered various pump options along with several other options.

Also available to the Repair Party Leader via the IDCTT are damage control templates, organization charts, communications information and ship's characteristics. Each of these items are required components of the damage control information library maintained in the Repair Locker. The damage control templates, for example, provide the RPL with the location of structural fire and flooding boundaries as designed in the ship's construction. This information allows the RPL to make rapid and accurate decisions regarding the placement of personnel and equipment for controlling the spread of fire and flooding. Additionally, information is readily available regarding the location and content of such critical spaces as weapons magazines, hazardous materials storage facilities, and flammable liquid storerooms, as well as magazine sprinkler systems, Halon protected spaces, and other installed firefighting assets.[3]

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[2] List is defined as the inclination of a ship about a fore and aft axis, while trim is the fore and aft inclination of the ship around an athwartships axis (Noel and Beach, 1977).

[3] Halon is a firefighting agent that can be employed from a remote location. This system is generally installed in engineering spaces, flammable liquid storerooms, and paint mixing and issue rooms.

E. PRIMARY GOAL OF IDCTT (RPL)

The intent of IDCTT (RPL) is to provide the student with practice in collecting and processing information, coordinating responses, and maintaining the overall damage control picture. These skills are critical to the performance of the Repair Party Leader as an individual, and development of these abilities will enhance the overall combat readiness of the unit. The skills mentioned above are difficult to learn outside of actually imposing damage control scenarios and then evaluating the Repair Party Leader's actions and responses. IDCTT provides the RPL candidate with unlimited opportunities to "test his or her mettle" against the computer, practicing personnel and equipment management, prioritization of effort and event sequencing. Feedback at the end of each scenario allows the RPL to determine his or her progress, identify areas of weakness, and focus on concepts requiring remediation. Additionally, the ship's Damage Control Training Team will have access to these training reports, enabling them to pinpoint areas of weakness that can be corrected via tailored training sessions.

F. FEATURES AND BENEFITS OF IDCTT (RPL)

IDCTT (RPL) has several embedded features. First, the system offers multiple scenarios including flooding, stability, fire, structural damage, pipe ruptures and personnel casualties. This software also provides the support necessary to conduct simultaneous interactive team training. The ability to modify scenarios at the local command level enables the ship's damage control training team to tailor training to specifically target areas of weakness identified during drills or other training sessions. IDCTT (RPL) provides immediate student performance evaluation and feedback, reinforcing the training received by the user. Finally, cross-platform connectivity between Windows-, Unix- and OS2-based operating systems allows for system flexibility. (Chief of Naval Operations (OPNAV N86D)).

Numerous potential benefits are available through use of IDCTT (RPL). Currently, the system supports training requirements including PQS and Fleet Exercises

and promotes standardization of fleet training. IDCTT (RPL) improves decision-making, teamwork and communications skills, reduces instructor and team-training workload, and supports flexible training schedules. The system will promote cross-training of key watchstanders by making available an educational tool that is fun and easy to use. Since the system allows for student performance evaluation and tracking, the qualification process can be standardized throughout the fleet, resulting in a greater transfer of knowledge from platform to platform.

One of the great difficulties facing the leadership aboard ship is ensuring the adequate training and cross-training of key members of the organic damage control organization.[4] This newly-devised system will allow individual members of the team to pursue, either with or without supervision, knowledge of ship's systems, proper event sequencing, intelligent application of assets based on priority and other important aspects of damage control without requiring the participation of every member of ship's company. This is a definite improvement over the current methods required for training, and, in the era of reduced shipboard manning, will result in enhanced readiness aboard the ship.

G. IDCTT (RPL) TEACHING POINTS

The IDCTT (RPL) software is designed to address doctrine, techniques, and procedures provided in various Navy damage control publications including the following:

- Surface Ship Survivability (NWP 3-20.31)
- Practical Damage Control (Naval Ships Technical Manual, Chapter 079)
- Repair Party Manual (COMNAVSURFLANTINST 3541.1C / COMNAVSURFPACINST 3541.4B)

[4] Cross training refers to the activity of preparing each member of the Repair Locker to be able to assume more than one role in the locker. This redundancy in training results in the Repair Locker being able to sustain casualties, and continue to execute it's damage control function without loss of continuity.

- Firefighting Ship (Naval Ships Technical Manual, Chapter 555, V1)
- Repair Party Leader Personnel Qualification Standard (NAVEDTRA 43119-G, Watchstation 318).

This coverage has been accomplished by establishment and incorporation of teaching points into each scenario developed for IDCTT (RPL). A complete list of teaching points is provided as Appendix A. As an example, one of the teaching points addressed in a fire scenario is the concept of establishing fire boundaries. The applicable teaching point states that "any physical barrier can be a fire boundary. Ideally, fire boundaries are the bulkheads, deck, and overhead surrounding the fire. Secondary boundaries are generally set at watertight subdivisions or airtight boundaries." The reference for this point is provided as Surface Ship Survivability (NWP 3-20.31). In this example, failure of the RPL to order fire boundaries, or order inappropriate fire boundaries will result in scenario events cascading to a predetermined "kill point," a stop in the software sequence from which the RPL cannot recover, and the ship is lost due to catastrophic damage.

Once the scenario is completed, the student is provided with a brief verbal and visual critique of his or her performance during the drill. This evaluation provides information on incorrect procedures, steps taken out of sequence, and other areas of difficulty. The assessment also provides a list of references that the trainee may review prior to undertaking a follow-on scenario.

III. THE REPAIR PARTY LEADER

Effective damage control is clearly an important factor in the survivability of a ship at sea. This effort plays an important role in the ability of the ship to sustain damage, reduce the impact of the damage on vital combat systems and maintain the ship's ability to continue its primary mission. An important aspect of how damage control contributes to surface ship survivability is the requirement to "improve the capabilities and skills of personnel to enable them to expeditiously handle recovery from combat scenarios or accidents and to promptly restore vital ship's systems." (NWP 3-20.31, paragraph 1.1)

The effective control of damage in a shipboard environment requires the participation of personnel from every echelon of the ship's manning structure. A typical shipboard damage control organization is as presented in Figure 2. As the senior person in the locker, the Repair Party Leader is in a position requiring expertise and knowledge

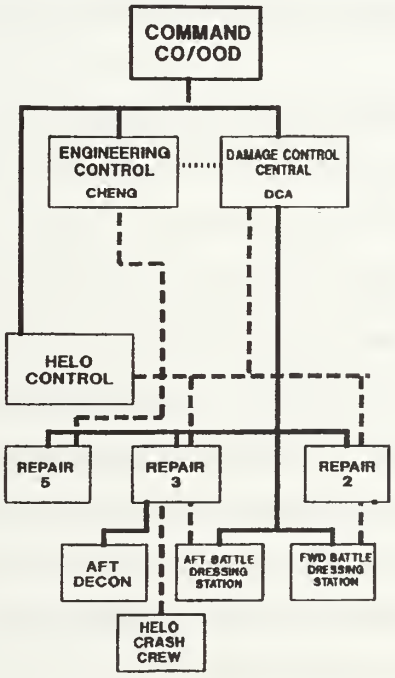


Figure 2. Shipboard Damage Control Organization (Typical) (from NWP 3-20.31, p. 2-12).

in the leadership and management of personnel assets, as well as a thorough knowledge of damage control theory, systems and fundamentals. Specifically, as stated in Surface Ship Survivability (NWP 3-20.31), the duties and responsibilities of the Repair Party include:

- Maintenance of stability and buoyancy.
- Maintenance of the ship's structural integrity and maneuverability.
- Making repairs to electrical and sound-powered telephone circuits.
- Administering first aid and transporting injured personnel to battle dressing stations without seriously reducing the DC capabilities of the Repair Party.
- Being familiar with the assigned area and related DC systems and equipment.

There are additional functions that lie within the purview of specific repair parties, but they will not be addressed in this thesis.

A. REPAIR PARTY LEADER TRAINING PROGRAM

1. Current Practice

Today, training for candidate Repair Party Leaders occurs at Fleet Training Centers in San Diego, California and Norfolk, Virginia. The course, Damage Control Repair Party Leader (K-495-0040), involves 10 days of instruction and covers a broad range of topics. The course mission is to "train personnel in pay grades E-5 and above in advanced damage control theory and techniques so that they may fill Repair Party Leader billets in the shipboard damage control organization, and to facilitate the proper management of repair party personnel in casualty situations under all shipboard readiness conditions." (Fleet Training Center, 1993)

The Repair Party Leader course is divided into two phases, each of which is five days in length. Both phases involve classroom lecture, written "practicals" and hands-on training evolutions. Phase II (second week) of the course focuses on aspects of Chemical, Biological and Radiological Defense. This thesis will study the impact IDCTT (RPL) has on student knowledge gained in Phase I.

2. Repair Party Leader School Instructors

Course instructors are highly qualified senior enlisted personnel (Chief Petty Officer or above) with vast experience in shipboard damage control. While on sea duty, each instructor has earned the Enlisted Surface Warfare Specialist designation, indicating the level of expertise that that individual brings to the job. Prior to becoming an instructor, the candidate must successfully complete the Instructor Training course. This course is the Navy's primer in presenting educational techniques to the instructor prior to them interfacing with the student. Additionally, Fleet Training Center San Diego Repair Party Leader instructors must successfully complete a local certification program prior to teaching a class.

3. Instruction at the Repair Party Leader School

Instruction at the school is presented primarily in the form of lecture and equipment demonstration. Class size is limited to an enrollment of 36 students, but the average class has approximately 25 students in attendance. During the period of instruction, students are exposed to information addressing Damage Control Organization, Communications, Repair Locker Coordination, Biological and Chemical Warfare Defense, Radiological Defense and Radiological Plotting. As part of the training, students are required to complete several written practical exercises, as well as spend one day in a damage control simulator ("wet trainer") and one period in a "confidence chamber" where they are taught the proper use and capabilities of the Navy's gas mask. The first week of training, Phase I, provides in-depth exposure to various areas of damage control, including fire fighting, flooding effects and stability. Emphasis is

placed on developing base skills in:

- repair locker administration and management
- damage control communications
- plotting and symbology
- plugging, patching and shoring
- other general DC topics

A student meets graduation requirements by scoring 80% or higher on two written examinations. The first examination, given at the end of week one, tests the student's knowledge of general damage control concepts and procedures, while the second examination covers aspects of Chemical, Biological and Radiological (CBR) Defense.

By the limited nature of the course, as well as restricted facilities, the student has a very limited opportunity to actually coordinate the activities of a Repair Locker, manage personnel and equipment, or exercise decision-making techniques. It is thought that use of IDCTT (RPL) as an educational augment at the school will enhance this opportunity, and result in an improved graduate, one more ready to contribute to his or her ship's damage control readiness.

4. Written Examinations Administered at Repair Party Leader School

The written examination is one of the main evaluative mechanisms used in the RPL course to determine a student's exit level of knowledge. The test is an exercise in memorization of general damage control idiom and discrete activities (e.g. pipe patching or construction of shoring), and does not provide any indication of the student's level of preparedness to actually lead a Repair Locker through an active damage control scenario. This method of assessment works well in determining whether the student meets the course graduation requirements. However, it is a common misperception in the fleet that RPL school graduates have spent a good deal of time actually managing and directing the

efforts of a Repair Locker while at the school. This leads the ship's senior damage control leadership to overestimate the ability the graduate possesses when he or she returns to the ship, and creates frustration for both the RPL candidate and supervisory personnel while the trainee is pursuing final qualification as Repair Party Leader.

B. PERSONNEL QUALIFICATION STANDARDS

For many years, the Navy has relied upon Personnel Qualification Standards (PQS) to provide a "map" for a candidate working towards completing a qualification for a specific watch station. These standards provide the Sailor with the minimum requirements he or she must meet in order to become qualified in the watch station in question. The PQS will indicate prerequisite qualifications that must be earned in order to begin the next program, and decomposes the qualification process into Fundamentals, Systems and Watch Station tasks.

NAVEDTRA 43119-G (Chief of Naval Education and Training) provides the applicable standard to which all Repair Party Leaders must comply in order to become qualified in that billet. Prior to commencing the qualification, the Sailor must have completed the prerequisites, which include the On-Scene Leader watchstation and fundamentals of Stability. Of course, the OSL PQS also has prerequisites, so the qualifications build on one another. From this PQS, it is clear that the focus of the training is based on coordination of Repair Party efforts in combating the various types of damage that can occur in a ship. Based on a comparison of the RPL Course syllabus and RPL PQS, it would appear that the school does not provide the hands-on opportunity that the candidate requires in order to complete the qualification, leaving that aspect of the training to the shipboard damage control training organization. This burden can be greatly reduced through use of IDCTT (RPL) as a vehicle to allow the RPL candidate to train individually and complete the various PQS requirements. As stated earlier, the damage control leadership reviewing trainee performance reports can maintain quality control by generating tailored training to address areas of weakness.

IV. METHODOLOGY

For this research, each student involved was given the option of not participating in the study. Of the 73 students attending the school during the three-month test period, all opted to participate in the experiment. Prior to taking the pre-test on the first day of the course, the students received a standard briefing regarding the purpose and goal of the study.

> This pre-test is given in support of research that is being done regarding the possible incorporation of interactive courseware in the training process at this school. Your participation in this study is purely voluntary, but you may have fun and really learn something! This test is given in order to determine the baseline level of knowledge each student has upon enrolling in the course. Your score on this exam will have no impact on the remainder of the course. The questions for this test will be multiple choice, true-false, and fill-in. Circle the correct answer or fill in the blank as required.

After taking the examination, students were given a brief overview and demonstration of the IDCTT (RPL) system which was installed at Fleet Training Center, San Diego, for the duration of the experiment.

A. EXPERIMENTAL DESIGN

In order to determine the effectiveness of the IDCTT (RPL), an experiment using the Untreated Control Group Design with Pretest and Posttest as described by Cook and Campbell (1979) was used.

1. Assignment of Students

a. March and April Classes

In this experiment, as in any other, the random assignment of students in the Repair Party Leader classes to either the control or treatment group was an important phase. Randomness in assignment of subjects to the two groups was critical in

ensuring the equivalence of the groups. Clearly, assignment of subjects to one or the other groups by means of a truly random method (i.e. coin toss) would be optimal. However, in the case of this experiment and based on experience with damage control training in the fleet, it was decided that several specific variables were considered important enough to include them in the process of assigning students to groups (Winkler and Polich, 1990). The groups were designated as indicated below:

- *Control Group.* This group consisted of members of the RPL School class that were not exposed to IDCTT (RPL)
- *Treatment Group.* This group was comprised of the remainder of the RPL School class, those who have their training augmented by use of the IDCTT (RPL)

To assure the random distribution of students, several factors were considered prior to making assignment of a particular student to a group.

- Sea duty experience
- Special/advanced qualifications held (i.e. ESWS)
- Gender
- Paygrade (officer and enlisted).

b. May Class

A different approach was taken with regard to assigning students to the control group for the May class. Volunteers to form the treatment group were solicited from the class in order to test the hypothesis that willing subjects would perform better than subjects selected at random. In its shipboard application, IDCTT (RPL) will be available to all members of ship's company. These sailors will be able to use the system at their discretion in order to enhance their knowledge of ship's systems and damage control theory, as well as improve individual decision-making ability. For these reasons, the aspect of volunteerism as a means of capturing the essence of motivation as a factor influencing learning was adopted for this class. While certainly not random, it was thought that this approach would provide some useful results.

2. Entrance Data

Entrance data (Appendix B) was obtained from each student. By collecting this information, it was possible to split the class in such a manner that approximately half the women assigned were placed in the treatment group, while the other half were designated to the control group. Similar divisions were made with respect to paygrade, special qualifications held, and sea duty experience. For obvious reasons, this information was not considered in the case of the May class. Details regarding the composite population, as well as demographics of the control and treatment groups are presented in section B.1 of this chapter and Chapter V.A.

3. Implementation of the Experiment

With the exception of the assignment of students to the treatment group mentioned in section IV.A.1.b, the experiment was identically conducted for the three classes. Both groups were subjected to a written pre-test (Appendix B) in order to establish a baseline level of knowledge. This test was, in fact, an alternate version of the actual test administered by the school to determine whether the student had met the requirements for successful completion of Phase I of the course. The cover sheet of the examination also included questions that were used for subject identification and data gathering that would be used in the analysis of results. The control group then proceeded through the school-prescribed training track (Fleet Training Center, San Diego, 1993), completing the course with the normally given post-test. The treatment group also passed through the normal curriculum, but was also given standard scenarios during the course requiring the use of the IDCTT. The normal post-test was then administered, completing this group's training. During week two of the course, each student sat before an oral board (examination), similar to boards used to qualify Engineering Officers of the Watch, Officers of the Deck and Command Duty Officers. These oral boards were conducted by two retired senior Naval officers, both with command experience. The "proctors" had no knowledge of the subject's training track, ensuring an unbiased evaluation. Questions asked at this board, and provided as Appendix C, were designed to determine level of knowledge based on standards established by the Repair Party Leader Personnel

Qualification Standard (Chief of Naval Education and Training). This oral examination, coupled with the end-of-phase written examination, fulfilled the requirement of the experiment's post-test.

B. STUDY SAMPLE

Each ship is required to provide a mid-grade to senior enlisted member or officer to serve as Repair Party Leader in each of the ship's Repair Lockers. These billets are active only when the ship is at Condition I, otherwise known as General Quarters, the highest state of combat readiness. Commonly, there are three Repair Lockers in a cruiser-destroyer type vessel, indicating the requirement to have at least three members of ship's company trained and qualified to fill the RPL billet. A requirement for serving as an RPL is satisfactory completion of the formal Repair Party Leader Course, as well as applicable Personnel Qualification Standards. This experiment was conducted using students attending the Repair Party Leader Course conducted at Fleet Training Center, San Diego. Each of these Sailors are prospective Repair Party Leaders aboard their assigned U.S. Pacific Fleet-ships, and are representative of the type individual who would logically be exposed to the training offered by the interactive RPL Trainer. In order to attend this course, each student must possess the following basic prerequisites:

- Paygrade E-5 or above
- Graduate of Advanced Shipboard Firefighting School
- Completion of rudimentary General Damage Control Personnel Qualification Standards.

The Repair Party Leader Course is generally convened once per month, although during some months, no class is held. Maximum class size is 36 students, but on the average, each class has approximately 25 students enrolled. This experiment was conducted using classes convened in March, April and May 1997. During this period, 73 students attended the class and participated in the study.

C. METRICS

For this research, several measures were collected. These included the previously mentioned pre-test administered prior to any exposure to IDCTT (RPL) or classroom instruction, as well as the regularly scheduled post-course examination required by the school. Finally, the oral examination was conducted for students in both the control and treatment groups. Data collected included the percentage of correct answers (of 30 questions) on the pre-test, percentage of correct answers on the post-test (of 50 questions) and performance by the student on the oral board. While the first two measures are clear, the oral board requires some explanation.

Oral board questions were developed using information contained in the Navy's damage control publications, PQS and based on the author's experience at previous Repair Party Leader qualification boards. The questions were designed to determine whether the students in the treatment group were further along than the control group in gaining the knowledge required to complete the requirements of Repair Party Leader qualification. Proctors were provided with specific instructions on how to conduct the boards, as well as guidance to be provided verbatim to the student before the board began (Appendix C). The student was read the question and then allotted one minute in which to provide an answer. Student responses that matched correct answers for the questions were marked on the proctor's sheet, and, when one minute had passed, the next question was asked regardless of the status of the previous question. Scores were calculated by determining the percentage of correct responses provided out of the 49 possible answers. Incorrect answers were not taken into account.

1. Variables

For this experiment, the dependent variable was the oral board score recorded by each participating Sailor. Independent variables include:

- Training system (i.e. RPL School, or RPL School and IDCTT) to which the Sailor was exposed
- Sea duty experience

- Gender
- Level of education
- Computer Aptitude Index generated from portions of the Armed Services Vocational Aptitude Battery (ASVAB) scores attained by the Sailor at the time of induction.

2. Computer Aptitude Index (CAI)

In order to capture some idea of each participant's computer literacy, ASVAB scores were obtained from the Defense Manpower Data Center in Monterey, California. As mentioned earlier, data was available for 52 of the 73 subjects of the research. In order to develop the CAI, aspects of all elements of the ASVAB were examined in order to determine and rate applicability as a measure of computer ability, problem solving and decision-making skills. An ASVAB test writer at DMDC provided insight as to the intent of each of these subtest areas, and helped in identifying the most logical set that would compose an index of computer ability (R. Hamilton, personal communication, June 19, 1997). Of these elements, three were determined to be possible indicators of these skills:

- Paragraph Comprehension (PC)
- Arithmetic Reasoning (AR)
- Coding Speed (CS).

Paragraph Comprehension requires the individual to use information to generate a decision. This function can be directly associated with the idea that IDCTT (RPL) provides the student with reports, status and assets available, and then requires the student to make decisions based on that information. While the ASVAB does not address damage control issues, the assessment of decision-making ability is generally similar. Arithmetic Reasoning evaluates logical problem solving. A parallel between this portion of the ASVAB and the requirements of IDCTT (RPL) exists much in the same way as mentioned for the PC subtest. Finally, the third element of the CAI, Coding Speed

measures the individual's ability for abstract reasoning. IDCTT (RPL) required this ability as the user must be able to postulate the downstream impact his or her actions may have on the progress of the scenario in order to successfully save his ship.

The DMDC database provided three versions of the ASVAB score for each of the 52 subjects. These scores include the Raw Score, Standardized Subtest Score and the Navy Composite Score. The Standardized Subtest Score was selected for incorporation into the CAI as it accounts for differences between the various versions of the ASVAB administered at Military Entrance Processing Stations (MEPS). By design, the Standardized Subtest Score ranges between 20 and 80, with a mean of 50 and standard deviation of 10. (R. Hamilton, personal communication, June 19, 1997)

Based on the information obtained from DMDC, the CAI was developed as Equation 1. The ASVAB does not provide a direct measure of an individual's computer prowess. Therefore, this equation assigns equal weight to the three components because

$$CAI = (PC + AR + CS) / 3 \qquad (1)$$

there is no way to determine which of the elements is the most important in describing or assessing an individual's computer ability.

V. DATA ANALYSIS AND RESULTS

The nature of data collected and the design of the experiment suggested using three different approaches for analysis. First, the complete set of data, including all 73 participants was examined. Second, data collected from the May 1997 Repair Party Leader class was analyzed. As will be shown, the difference between mean treatment and control group oral board scores for this class was significantly higher than that of the other two classes, creating interest about the data set. Finally, a censored data set, one taking into account information obtained from Defense Manpower Data Center, was studied.

A. SAMPLE DEMOGRAPHICS

A wide variety of skill levels, ratings and experience was represented in the classes studied. Additionally, each class was comprised of officers, enlisted personnel, men, women, and members of various ethnic groups and races. In order to establish a profile for each participant, data regarding educational background, race, gender and performance on standardized aptitude examinations was collected from the Defense Manpower Data Center (DMDC) master files. Unfortunately, of the 73 participants, DMDC held records on only 52 persons. Of the 21 social security numbers that produced no matching record, 12 were associated with the treatment group while the remaining nine were part of the control group. Further, 18 of the 21 records that produced no match in the DMDC database were junior officers, Lieutenant or below. It is possible that some of these officers never took an aptitude test, or that they have not been in the Navy long enough for the data base to reflect any information. The three remaining unmatched personnel were a Chief Petty Officer, Chief Warrant Officer and a Second Class Boatswain's Mate. The absence of information on these Sailors is inexplicable. Level of education data, however, was obtained on all 73 participants. Table 1 provides demographic information regarding the overall sample population.

Demographics and Background	Total	Control	Treatment
Sample Size (N)	73	36	37
Male (percent)	83.56	86.11	81.11
Pay grade (rank) Distribution (percent)			
E-5	10.96	8.33	13.51
E-6	24.66	27.78	21.62
E-7 through CWO4	24.66	30.56	18.92
O-1 and O-2	34.24	30.56	37.84
O-3 and above	5.48	2.77	8.11
Educational and Aptitude Characteristics			
Previous Education Distribution (percent)			
Some college or more	42.46	38.89	45.95
High School Diploma	38.36	38.89	37.83
GED Certificate	4.11	2.78	5.41
Less than High School Diploma	1.37	0.00	2.70
Unknown	13.70	19.44	8.11
Career Characteristics			
Average Sea Experience (months)	48.49		
Warfare Qualified (percent)[1]	42.47		

Table 1. Sample Demographics.

Clearly, the sample was overwhelmingly male, with only 16.5% of the participants being female. This is not considered unusual, as the Navy has only recently opened the majority of shipboard billets to females. Interestingly, among the officers in the sample, 26% were female, and most were assigned to pre-commissioning units. Of this group of female officers, 83% were assigned to the treatment group. Since the Repair Party Leader billets are normally held by senior enlisted personnel and junior officers, it is not surprising that almost 59% of all participants in the study were between the ranks of Chief Petty Officer (E-7) and Lieutenant (junior grade). Finally, the average

sea experience of the sample group shows the fact that several of the junior officers had no previous shipboard experience, while some of the senior enlisted personnel had upwards of six years at sea.

As mentioned previously, three separate Repair Party Leader classes participated in this study. Figure 3 shows the officer and enlisted composition of each of the three classes, as well as the composite group when considering all 73 study participants. As this graph indicates, the first two classes had smaller officer representation (30.3% and 16.7% for the March and April classes) than did the May session (57.7%). This

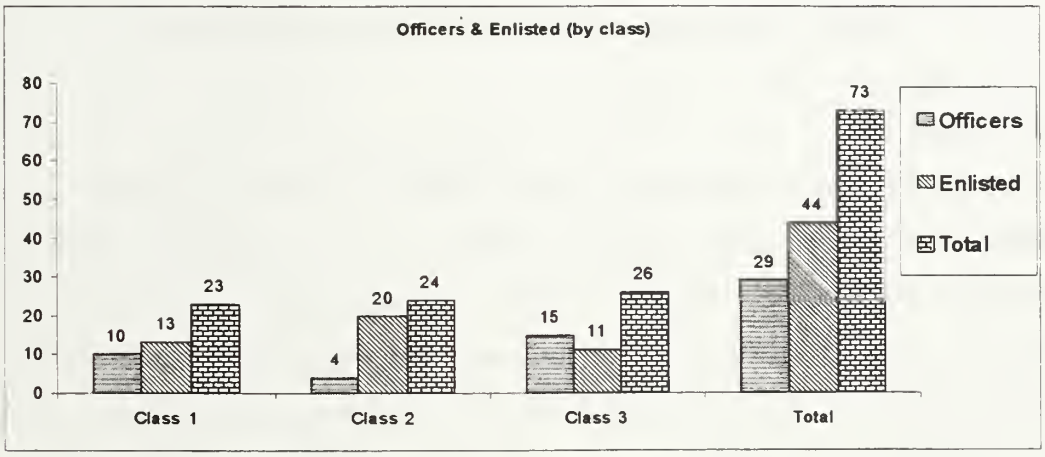


Figure 3. Breakdown by rank for each RPL School class.

unbalanced condition may influence results, and bears attention. Figure 4 provides information regarding the distribution of officer and enlisted personnel by class convening date as well as group assignment. Figure 4 shows that class 3, convened in May, has a much higher percentage of officer representation in the treatment group, 62%, as opposed to classes 1 and 2 (50% and 25% respectively). The effect of this distribution will be examined to determine impact on the overall result of the study. Additionally, 54% of the May class treatment group was composed of officers, as opposed to 36% and 8% of the March and April sessions. Considering these disparities may help explain

[1] Some participants have earned qualification as a warfare specialist (Surface Warfare Officer or Enlisted Surface Warfare Specialist). Information regarding qualification requirements for these designations is available in various Navy directives, including the Military Personnel Manual (MILPERSMAN).

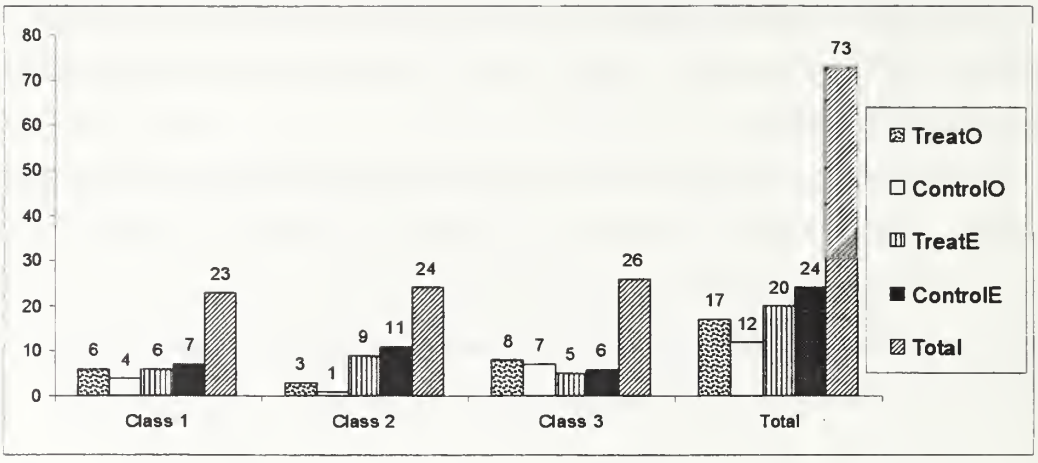


Figure 4. Distribution of Officers and Enlisted (by class and group).

results obtained.

In order to utilize education level and aptitude examination information provided by DMDC, the data set was censored to include only those personnel for whom this information was available. While this reduced the sample size to 52, it is important to determine if there is any relationship between performance and education/aptitude. Therefore, two presentations will be made; the first neglecting education and aptitude, but considering the entire data set, and a second that considers these factors in the analysis.

Table 2 provides information regarding the censored data set. As mentioned earlier, DMDC was able to provide information on 52 of the 73 study participants. The information in Table 2 is provided to enable analysis of the impact the subject's level of education and aptitude as determined by AFQT/ASVAB tests administered upon induction into the Navy.

Demographics and Background	Total	Control	Treatment
Sample Size (N)	52	27	25
Male (percent)	84.62	81.48	88.00
Race Distribution (percent)			
White	69.24	74.07	64.00
Black	15.38	14.82	16.00
Other	15.38	11.11	20.00

Pay grade (rank) Distribution (percent)			
E-5	13.46	7.41	20.00
E-6	34.62	37.04	32.00
E-7 through CWO4	30.76	33.33	28.00
O-1 and O-2	17.31	18.52	16.00
O-3 and above	3.85	3.70	4.00
Educational and Aptitude Characteristics			
Previous Education Distribution (percent)[2]			
Some college or more	26.09	30.43	21.74
High School Diploma	54.35	52.18	56.53
GED Certificate	4.35	0.00	8.69
Less than High School Diploma	2.17	0.00	4.35
Unknown	13.04	17.39	8.69
AFQT Score (mean)	66.26	66.74	65.78
AFQT Mental Category (percent)			
I (93-99 percentile)	15.22	17.39	13.04
II (65-92 percentile)	39.13	43.48	34.78
IIIA (50-64 percentile)	19.56	8.69	30.43
IIIB (31-49 percentile)	23.91	26.09	21.74
IV (10-30 percentile)	2.17	4.35	0.00
V (1-9 percentile)	0.00	0.00	0.00

Table 2. Sample Population Demographics (Censored Data).

Table 2 shows that the distribution between the control and treatment groups is fairly consistent across the spectrum of variables. The small percentage of subjects that have earned a college degree skews the reflected percentages while the raw numbers are relatively close. As would be expected, the vast majority of subjects fall into Mental

[2] Data provided by DMDC indicated that of the 52 subjects, 6 had unknown AFQT scores. As such, these personnel were excluded from the calculation of education level, mean AFQT and Mental Category figures.

Categories IIIA and II. The presence of one Mental Category IV subject in the treatment group is somewhat dampened by that group's larger percentage of Category I personnel.

Figure 5 provides a summary of the censored data set. When considering this data, the officer population has been reduced such that representation in the March and May classes is fairly consistent (35% and 27%), while officers comprise only 5% of the

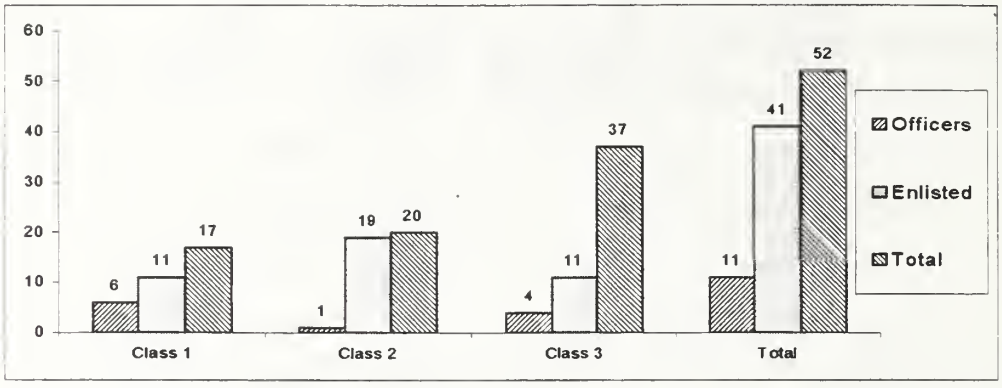


Figure 5. Officers and Enlisted (by class) for the Censored Data Set.

April class. Figure 6 provides the distribution of officers and enlisted by class and group for the censored data set. With the officer population reduced from 29 to 11, one

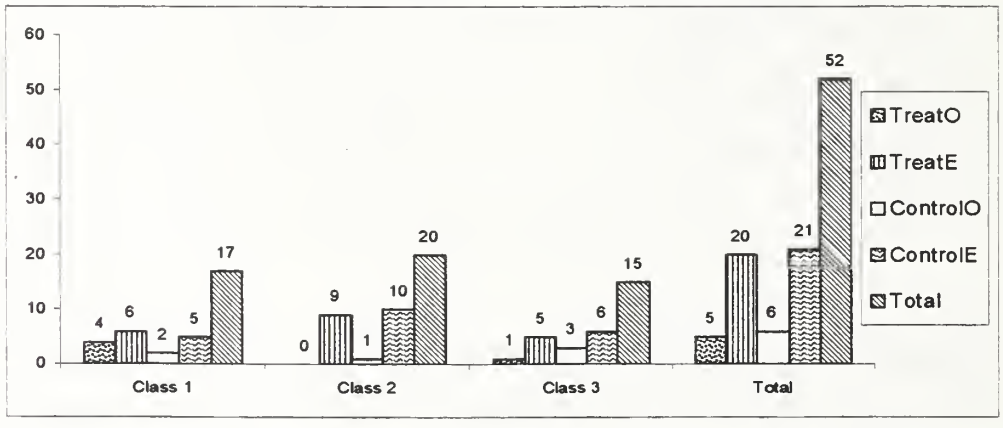


Figure 6. Distribution of Officer and Enlisted (by class and group) for the Censored Data Set.

would expect there to be an effect in the distribution of officers throughout the three classes. From this graph, it is clear that the distribution of enlisted personnel between the

control and treatment groups is consistent across all three classes. With respect to the officers, there are none represented in the April session's treatment group, and only one in the May treatment group. Over the spectrum of classes, however, the officers are evenly divided between the control and treatment groups.

B. ANALYSIS OF THE COMPLETE DATA SET

Prior to beginning the experiment, it was expected that the subject's rank (i.e. whether officer or enlisted), level of education, sea experience, advanced qualifications, pre-test score and time actually spent using the IDCTT (RPL) would be important factors in determining how well the individual performed during the post-treatment oral board. With this in mind, data was collected for the 73 participants to address these variables. Appendix D provides the complete data set; names and social security numbers of the participants are not included because of Privacy Act restrictions.

1. Variable Selection

As an initial action, stepwise regression was employed in order to assist in the selection of variables. (Hamilton, 1992) This search strategy helped identify the variables that had the most significance in the prediction of a student's performance during the Oral Board. The difficulties Hamilton (1992) discusses regarding this method were noted, but it was decided that stepwise regression provided the simplest means of determining the optimal variable combination.

Appendix E provides the results of stepwise regression on nine independent variables using the "forward inclusion" method provided by S-Plus. In this method, the process starts with no independent variables in the model, and then first adds the variable that has the largest simple correlation with the dependent variable. At each subsequent step, the independent variable that provides the largest decrease in R^2 is added to the model. (Hamilton, 1992) As shown in Appendix E, the variables were added in the following order:

1. Group
2. Class
3. Pre-Test Score
4. Rank
5. ESWS Qualification
6. Education
7. IDCTT (RPL) Exposure Time
8. Sea Duty Experience
9. Gender

Figure 7 provides a graphical representation of the impact the addition of each variable has on the reduction in the residual sum of squares (numbers on the x-axis correspond to

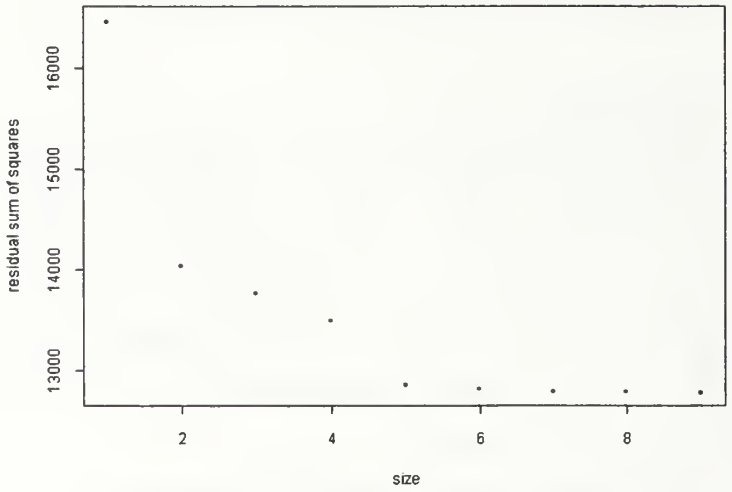


Figure 7. Variable Selection via Stepwise Regression.

the independent variable listed above). As shown in Figure 7, the curve has a steep slope until the model contains five variables, and then flattens out, indicating that the addition of variables six through nine do not provide a significant decrease in R^2. This result provides visual evidence that level of education, time spent working through scenarios using IDCTT (exposure time), sea duty experience or gender did not noticeably influence the subject's performance on the Oral Board.

2. Initial Data Analysis

In order to examine the data, a tree-based model was developed. ("S-Plus Guide to Statistical and Mathematical Analysis", 1995) This model was used to further screen variables as to their relative importance and summarizes the complex multivariate data set generated by the study. In this model, predicted values of the independent variable are made based on various partitions of the data. Logical expressions are displayed at each split, providing information regarding the branches that follow. As is the convention, the logical expression is evaluated as being true for branches to the left and false for right branches. Figure 8 provides the tree-based model generated by the complete data set using all predictor variables. This model provides some interesting

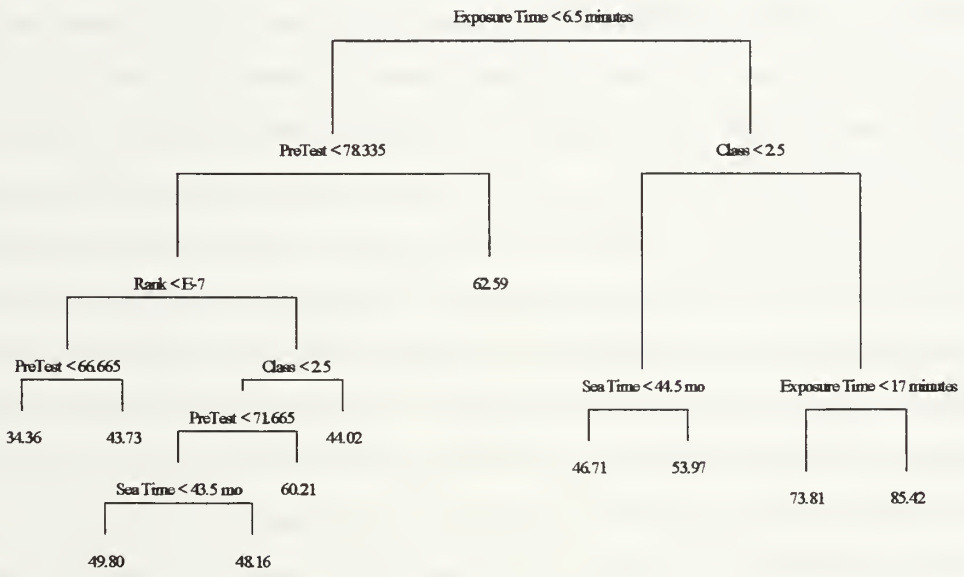


Figure 8. Tree-based model (Complete data set).

insight into the data. Six members of the treatment group spent less than 6.5 minutes using the interactive system. Based on the partitioning algorithm embedded in the tree-based model method, no significant differences exist between the control and treatment groups when exposure is less than 6.5 minutes. For all practical purposes then, the branches on the left side of the root (IDCTT exposure time less than 6.5 minutes) can be considered representative of the control group, while the right side is associated with the

treatment group. One feature provided by the tree-based model is a visual indication of the importance of each variable. As can be seen in Figure 8, the longest vertical branch of the treatment group-side of the tree is associated with the parent split "class." The longer the branch, the more important the model considers the variable. As for the control group, the most important variables are pre-test score, followed by rank.

a. Control Group Analysis

With respect to the control group, the first partition in the tree is based on the pre-test score recorded by the student (Figure 8). Students that earned a score in excess of 78.335 could be expected to answer 62.59% of the oral board questions correctly, regardless of rank. This figure is higher (in most cases, substantially so) than oral board scores earned by students not doing as well on the pre-test. Mid-grade enlisted students (paygrade E-5 and E-6, with respective rank indicators of 1 and 2)[3] scoring between 66.665 and 78.335 could be expected to correctly answer 43.73% of questions asked at the oral board, while those posting pre-test scores less than 66.665 would correctly answer only 34.36%. Within the control group, the class in which the student was enrolled was a factor for students in paygrades E-7 through O-4 (rank indicators of 3 through 5). For these students, those in the May RPL class (class 3) scored 44.02% on the oral board, while those in classes convened in March and April (classes 1 and 2, respectively) earned slightly higher scores. As shown in the fourth echelon, students in the first two classes scoring higher than 71.665 on the pre-test did significantly better on the oral board. Even though the algorithm continues to split the data, it is evident that sea time was not a factor producing great differences in expected oral board scores within the control group.

b. Treatment Group Analysis

As mentioned earlier, the right side of the tree in Figure 8 represents the model associated with the treatment group. While much simpler, this portion of the tree

[3] Subjects in this study consisted of personnel of paygrade E-5 (mid-grade enlisted) through O-4 (midgrade officer). In order to simplify analysis, integers representing the paygrades were assigned as follows: 1 – E-5, 2 – E-6, 3 – E-7 through W-4, 4 – O-1 and O-2, 5 – O-3 and above. An indicator of 2.5, therefore, delineates the boundary between E-6 and E-7.

provides some interesting information regarding the differences in the three classes. In this case, the algorithm partitioned the data based initially on the classes, dividing the set into March and April classes, and the May class. Within the March and April classes, sea time was an important factor in predicting performance on the end-of-course oral board. Those personnel with less than 44.5 months of sea duty could be expected to correctly answer 46.71% of the oral board questions, while those with more time at sea would be expected to score 7.26% higher. It is interesting to note that sea time was considered to be the eighth most important variable when stepwise regression was employed. For students in the May class, IDCTT (RPL) exposure time was the partitioning factor. In this case, those students with greater than 17.5 minutes of system contact time scored 11.61% higher than did those with less time running damage control scenarios. The most interesting aspect of the treatment group-side of the tree is the range of expected oral board scores. These scores range from 46.71 to 85.42, a very wide span. This variation raises questions regarding data collected from the May RPL class, and provides support for the three-phase analysis.

c. Combined Analysis

As stated earlier in this chapter, the inconsistencies in oral board performance across the three classes is of interest. Since the tree presented in Figure 8 indicates a large difference in performance between the March and April classes and that of the May class, a second tree-based model was constructed. In this model (Figure 9), the left branches of the tree correspond to the control group, while the right side represents the treatment group. In this model, it is clear that the May class treatment group could be expected to earn substantially higher scores on the oral board than any other group, while control group oral board scores are roughly equivalent across the three classes. As the May class treatment group was composed of volunteers, this striking result may provide evidence supporting the belief held by many educators that "...motivation is the ultimate key to success in the classroom." (Poirot, 1992)

3. Analysis of Variance

As presented earlier, stepwise regression identified five significant independent variables. Based on that regression, ANOVA was conducted on a model constructed using these variables, with the oral board score as the response variable. Appendix F provides the results of this analysis, including interaction. A simple additive linear model was also constructed using the variables identified in the stepwise regression. As discussed by Hamilton (1992), the selection of variables using a search strategy such as

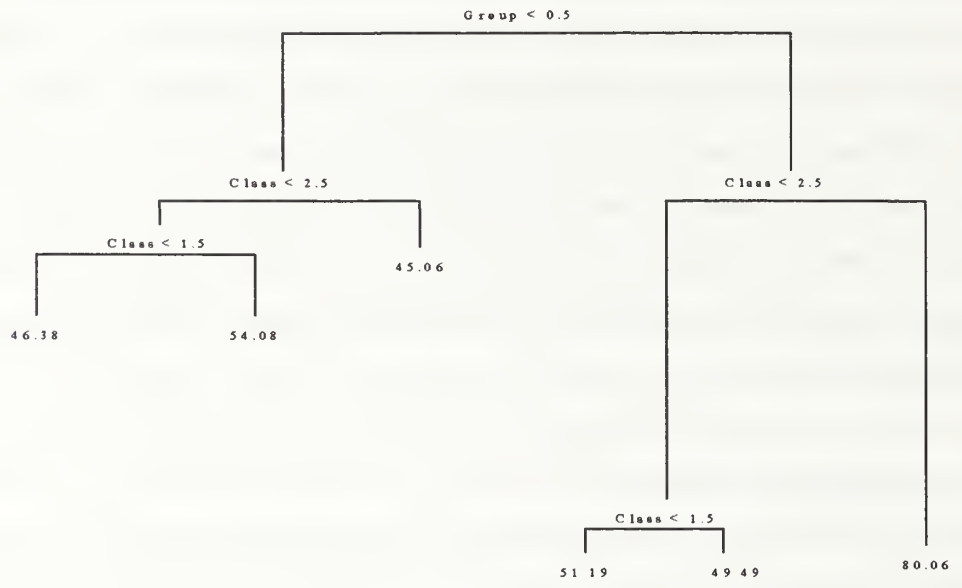


Figure 9. Tree-based model of Complete Data Set (Group only).

as stepwise regression is not without pitfalls. Hamilton states that p-values generated using these variables are "unrealistically low," casting doubt as to the meaning of the significance of each variable. With this in mind, Hamilton recommends using p-values for descriptive value only. Therefore, the following analysis must be accepted with caution. Table 3 shows that of the five variables, group and class are highly significant, rank and ESWS qualification are moderately significant, and pre-test score is insignificant. This simple model produced an R^2 value of .3309, indicating that the model variables account for only 33% of the variance. As shown in the results of ANOVA (Appendix F), of the five variables in the model, group, class and ESWS qualification are significant predictors of a student's performance on the oral board,

while pre-test and rank are insignificant at α=0.05. The complex and uninterpretable interactions revealed by ANOVA suggested the adoption of a simple additive model using these three independent variables.

	Value	Std. Error	T value	Pr(>|t|)
Intercept	12.8303	11.4069	1.1248	0.2647
Group	11.3005	3.2835	3.4416	0.0010
Class	6.8078	1.9894	3.4221	0.0011
PreTest	0.1665	0.1388	1.2000	0.2344
Rank	2.9968	1.6182	1.8520	0.0684
ESWS	7.2689	3.9908	1.8214	0.0730

Table 3. Linear Model with Five Variables Model.

Figure 10 is a boxplot comparison of control and treatment group oral board scores. From this plot, it would appear that the treatment group recorded significantly

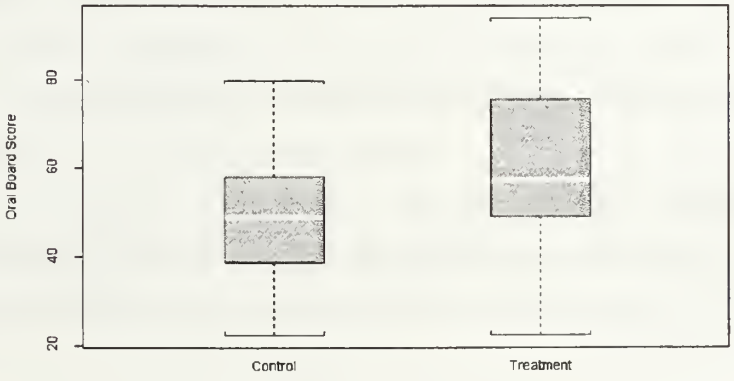


Figure 10. Boxplot comparison of Oral Board Scores (Complete Data Set).

higher scores on the post-course oral board. However, variability between the two groups is inconsistent. The median score for the treatment group, represented by the white horizontal line across the box, was 57.14, while the control group median score

was 48.98. While this is a large difference, it is unclear as to whether the difference was the result of the treatment, a combination of the interaction of the independent variables, or chance. In order to determine the source of the difference, boxplots were constructed comparing the control and treatment group oral board scores as influenced by the important independent variables identified by ANOVA (class and ESWS qualification). As Figure 11 shows, there was greater variability for those students previously ESWS qualified, and those students enrolled in the May session (class 3). The overlap of the quartile boxes would indicate that there is no difference between oral board scores when these variables are considered.

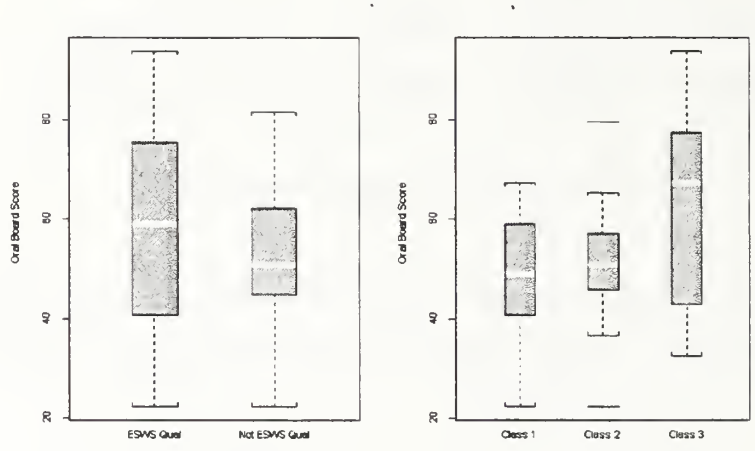


Figure 11. Boxplots of Complete Data Set variability.

4. Hypothesis Testing

In order to determine the effectiveness of IDCTT (RPL) over conventional schoolhouse methods in the case of the complete data set, the following hypothesis was tested:

H_o: The mean oral board score recorded by the control and treatment group were equal.

versus

H_1: The treatment group recorded a higher mean oral board score.

As a prelude to actually testing the null against the alternative hypothesis, the power of the statistical test was calculated (Appendix G). Power is defined as the probability of finding the null hypothesis to be wrong, given the decision rule and the true parameter value under the alternative hypothesis (Larsen and Marx, 1986). In other words, power is a measure of the sensitivity of the test to detect differences in the parameters being compared. In the case of this analysis, the parameter of interest is the mean of control and treatment group oral board scores. Higher power over a broad range of hypothesized differences between the means would be ideal; of course, common to all power functions is a reduced capability to detect differences as they approach zero.

For this analysis, it had to be shown that the variance of control and treatment group oral board scores was equal. In order to do this, a two-sided F test was conducted. The following hypothesis was checked using this test:

H_o: The variances of the mean oral board scores recorded by the control and treatment group were equal.

versus

H_1: The variances were not equal.

With an F-statistic equal to 1.9855, a p-value of 0.045 was produced. Based on this result, and at a level of significance of 0.05, the null hypothesis would be rejected. This small margin of rejection, however, allows for the statement that the variances were not significantly different, and testing could continue.

With equal variance and normality (essentially) shown, the test statistic generated (Equation 2) is distributed as a t random variable with n + m - 2 degrees of freedom

$$t = \frac{(\overline{Y}_t - \overline{Y}_c) - \Delta}{\sqrt{\frac{S_p^2}{n + m}}} \qquad (2)$$

(where n and m are the sizes of the control and treatment group samples). When sample size is large, the *t* distribution looks Normal. As such, the power functions developed are Normal approximations.

Figure 12 is the power function developed using the complete data set. As would be expected, power is lowest when the control and treatment groups are hypothesized to be equal. In fact, the power at this point is equal to the level of significance of the test, in this case $\alpha = 0.05$. What Figure 12 provides is an indication of the test's ability to detect differences between the means over the range of –30 (i.e. the control group mean is larger) to 30 (i.e. treatment group mean is larger). As shown, this test has relatively high power and can be expected to detect a ten percent difference between the means with probability approximately 0.40. As the hypothesized difference becomes larger, the

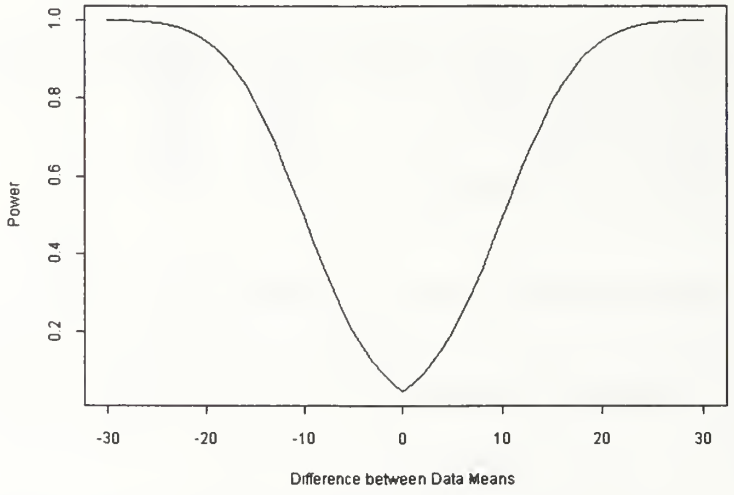


Figure 12. Power Function for Complete Data Set.

power of the test increases until it approaches one. So, for a large difference between the control and treatment group means, this test is likely to detect a difference. Conversely, for small differences (less than ten percent), the power of the test is limited.

Prior to testing this hypothesis, however, the data was explored to determine the nature of the underlying distribution. Figure 13 provides four plots used as diagnostic

tools with which to begin the analysis of the data. The top left plot is a histogram of the data. The lower left plot is known as a density plot. This plot is essentially a smooth version of the histogram and provides smooth estimates of population frequency or probability density curves. As they are similar, the density curve and histogram should have basically the same shape. However, differences in how the software package generates bin sizes can result in differently shaped plots. Based on the histogram in Figure 13, the data appeared to be positively skewed. By applying a power transformation (raised to the 0.8 power), the distribution of the data was made more symmetrical. The histogram and boxplot (Figure 14) indicate the effect of the transformation. Based on the visual evidence provided in Figure 14, the transformed data was assumed to be normally distributed, permitting the application of standard statistical tests of the previously mentioned hypothesis, using the transformed data.

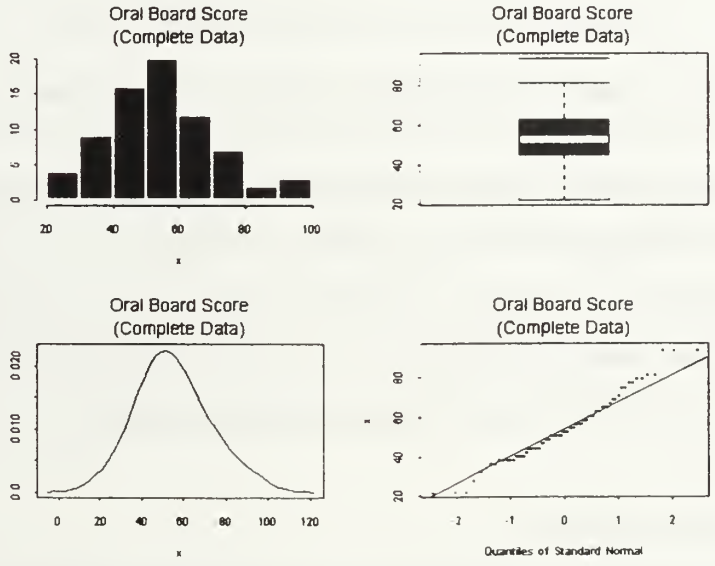


Figure 13. Diagnostic Plots for Complete Data Set.

To test the hypothesis that the mean oral board scores recorded by the control and treatment group were equal, a two-sample t test was conducted on the transformed

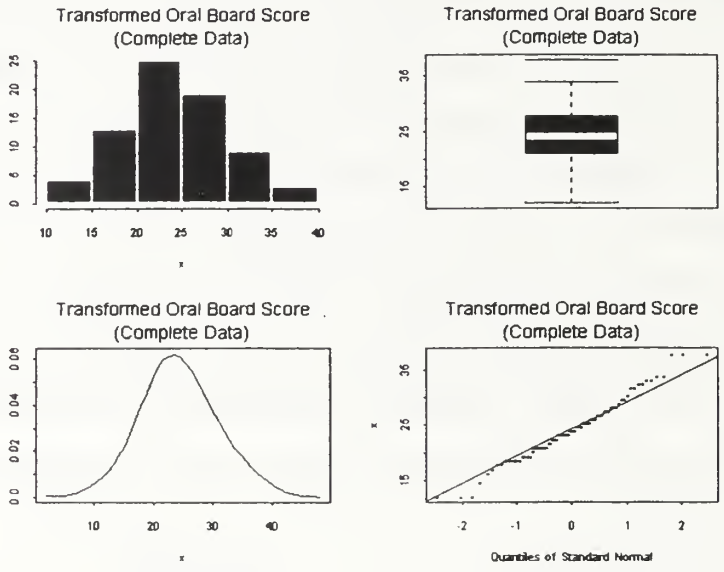


Figure 14. Diagnostic Plots for Transformed Data (Complete Data Set).

data. This test indicated that at a level of significance of 0.05 and a *t*-statistic of 3.4026, there was a difference between the means (p-value = 0.0006), and the null hypothesis was rejected. The treatment group, in fact, attained a mean oral board score 20.26% higher than that of the control group (60.78 to 48.47). It could not be measured, however, the exact contribution use of IDCTT (RPL) had in this learning benefit.

5. Analysis of Results

Since this experiment was based on the assertion that use of interactive courseware as an instructional aid benefits learning, the discovery that the group the student was part of (i.e. control or treatment) was significant is not surprising. As previously mentioned, the treatment group used volunteers from the May class, so the oral board performance differences between the classes could be expected. Table 4 provides a principal component analysis of the independent variables in order to further explain the factors contributing to differences in oral board scores. From this table, the

class the student was in accounts for 64% of the variance in the model. However, 31% of the variance is explained by group affiliation. This information provides further

	Standard Deviation	Proportion of Variance	Cumulative Proportion
Class	40.25	0.6375803	0.6375803
Group	27.88	0.3060058	0.9435861
Rank	11.72	0.05407455	0.99766068
Education	2.03	0.001618563	0.999279238
ESWS	0.90	0.0003188014	0.9995980396
Gender	0.79	0.0002443316	0.9998423712
Sea Time	0.44	0.00007777285	0.99992014409
Pre Test	0.33	0.00004408595	0.99996423004
Exposure Time (< 6.5 minutes)	0.30	0.00003576996	1.00000000000

Table 4. Variance as explained by Principal Components.

evidence that use of IDCTT (RPL) provides some educational benefit to the students in the class. However, the fact that IDCTT (RPL) exposure time was inconsequential creates concern as to the quantitative advantage gained by students in the treatment group. The importance of the class the student was enrolled in has to be considered as a confounding variable. Since this component accounted for a majority of the variance in the model, it must be addressed. Analysis of data collected from the May class will hopefully clarify this issue.

C. ANALYSIS OF DATA COLLECTED DURING MAY 1997 RPL SCHOOL CLASS

Techniques employed in examining the complete data set were used in exploring data collected from the May RPL School class (Appendix D). As mentioned earlier in this chapter, obvious differences in oral board performance among members of the treatment groups necessitated this separate analysis.

1. Variable Selection

Stepwise regression was employed using the eight available variables. As illustrated in Figure 15, this regression identified six variables that made important

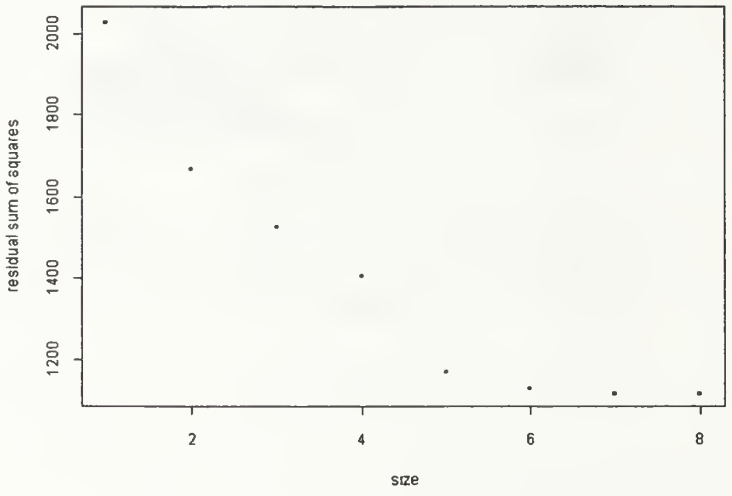


Figure 15. Variable Selection via Stepwise Regression.

contributions to the reduction in the residual sum of squares. As such, the following variables were used in the construction of a simple additive linear model and conduct an ANOVA:

1. Group
2. Pretest Score
3. Exposure Time
4. Sea time
5. ESWS Qualification
6. Education

2. Distribution of the Data

Figure 16 provides a series of diagnostic plots used to determine the characteristics of the underlying distribution of the data. The QQ-plot and boxplot

provide an indication that the data set has light tails and very few outlying points. The information provided in Figure 16 does not, however, provide much clarification as to the

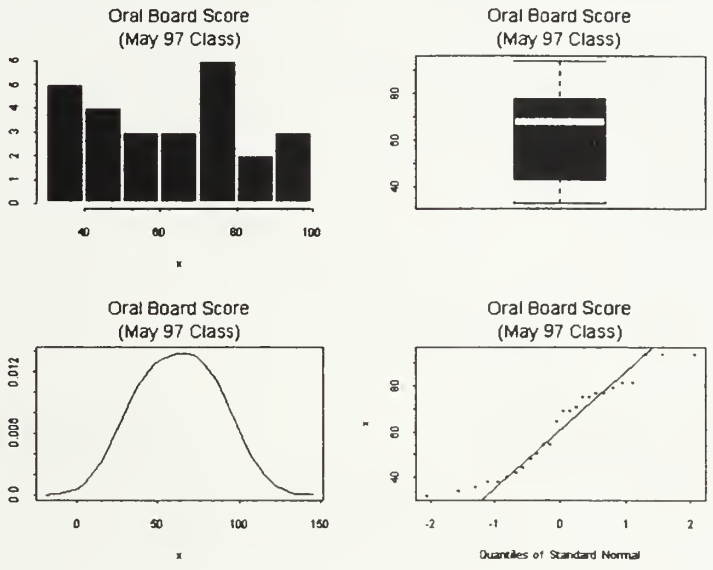


Figure 16. Diagnostic plots for the May 97 Class.

distribution of the data. To further examine the data, composite goodness-of-fit tests were applied. In these tests, the parameters required (mean and standard deviation) were estimated from the data. As a result of parameter estimation, the goodness-of-fit tests were limited in their ability to determine the distribution and specific parameters underlying the data. In fact, composite goodness-of-fit tests can only determine the family of distributions to which the data belongs ("S-Plus, Guide to Statistical & Mathematical Analysis", 1995).

The null hypothesis for these tests was that the cdf of the data equaled the Normal distribution, with the alternative being that they were not equal. Figure 17 is a plot of the empirical cdf and hypothesized Normal cdf. This plot provides a foundation that the data may be assumed to belong to the Normal family of distributions, a conjecture that was further examined by goodness-of-fit tests. The first goodness-of-fit test applied was the one-sample Kolmogorov-Smirnov test. Using the estimated parameters, the null hypothesis could not be rejected (p-value = 0.5) at a 5% level of significance. In order to confirm this result, the chi-square goodness-of-fit test was applied to the same

hypothesis. Again, the results of this test do not permit the rejection of the null hypothesis that the data is from a non-specific Normal distribution (p-value = 0.1649). In both cases, the p-values returned caused suspicion about the null hypothesis, but did not

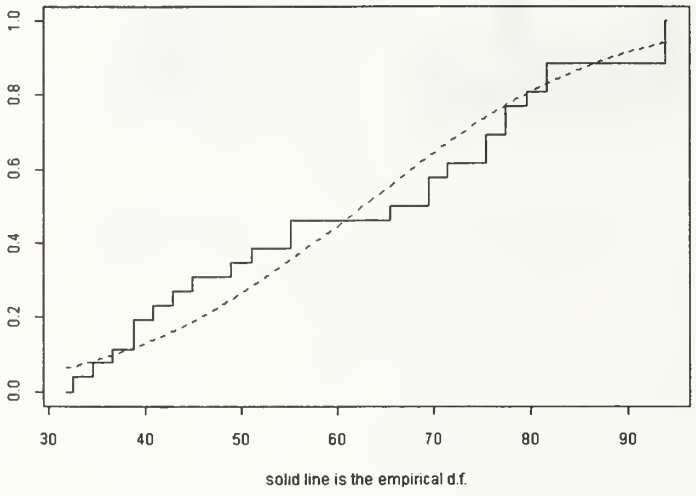


Figure 17. Empirical and Hypothesized Normal CDF's.

allow for definite rejection at the level of significance specified. In particular, the chi-square test p-value was suspect as the test was applied to a small sample, when it is most effective for large data sets ("S-Plus, Guide to Statistical & Mathematical Analysis", 1995).

Based on the visual evidence presented in Figures 16 and 17, as well as the results provided by the goodness-of-fit tests, the data were assumed to be Normally distributed and were analyzed as such.

3. Initial Data Analysis

As mentioned earlier in this section, group, pre-test score, exposure time, sea time, ESWS qualification and education were found by stepwise regression to be the most important factors with regard to the May 97 Repair Party Leader School class

(Appendix E). A tree-based model, as discussed in Chapter IV.A.2, was constructed, using all six variables. As shown in Figure 18, the partitioning algorithm identified only

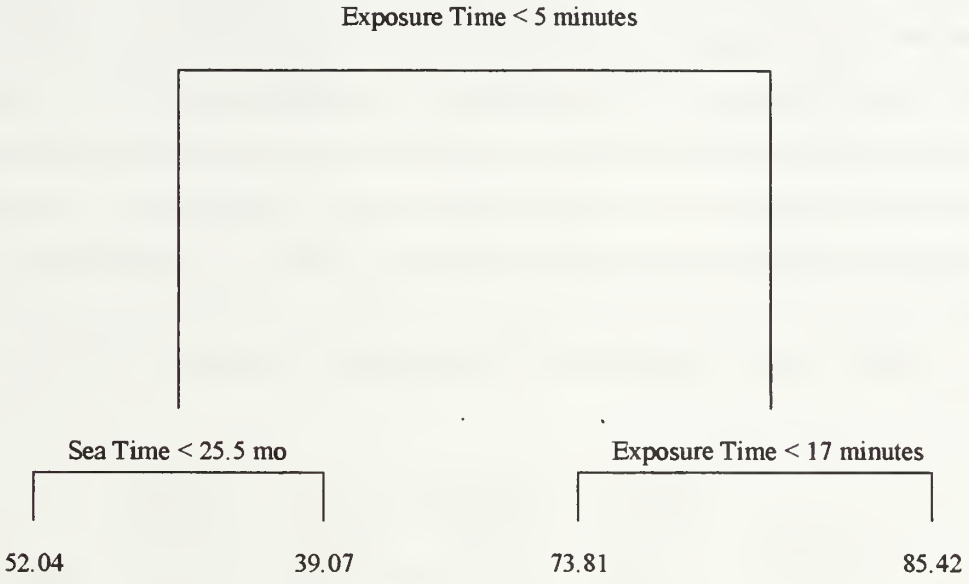


Figure 18. Tree-based model (May 97 class data set).

two of the variables as being significant for analytical purposes. The first division was made based on IDCTT exposure time. In Figure 8 the partitioning algorithm split the data based on 6.5 minutes of exposure time. Using the May 97 class data, this same algorithm divided the data at five minutes of exposure. All 13 members of the treatment group in the May class had greater than five minutes of use of IDCTT (RPL). Thus, as in the previous tree (Figure 8), the left branch of Figure 18 represents the control group (exposure time < 5 minutes), while the right side corresponds to the treatment group. It is clear from Figure 18 that the May class treatment group performed at a much higher level on the oral board than did the control group. With regard to the control group, sea duty experience was a major factor in influencing oral board performance, with the division made at just over two years. In this particular class, the treatment group scored an average of 78% higher on the oral board than did the control group.

4. Analysis of Variance

In order to determine the importance of the independent variables identified in the stepwise regression, ANOVA was conducted. Appendix J provides the complete result of this procedure, and includes all interaction effects. From this ANOVA, only group is significant at the 0.05 level, while pre-test score and ESWS qualification would be significant at a 10% level of significance. This result was expected, as the difference in oral board scores between the control and treatment groups was substantial. In order to provide for comparison with the results attained by ANOVA, a simple additive linear model was developed using the same independent variables. Table 5 shows that at $\alpha = 0.05$, group and sea duty experience were significant. At a 10% level of significance,

	Value	Std. Error	t value	Pr(>|t|)
Intercept	35.9033	13.4969	2.6601	0.0155
Group	21.6808	6.0395	3.5898	0.0020
PreTest	0.1445	0.1732	0.8340	0.4146
ExpTime	0.4137	0.2088	1.9809	0.0623
SeaTime	-0.2300	0.1006	-2.2857	0.0339
ESWS	13.0991	6.6580	1.9674	0.0639
Education	0.6712	0.8156	0.8229	0.4208

Table 5. Linear Model for Six Variables (May Data Set).

IDCTT (RPL) exposure time and ESWS qualification were shown to be important factors in predicting oral board performance. The linear model generated in the case of the May class data provided a very good fit and explained almost 89% of the variance in the data ($R^2 = 0.8865$).

Principal component analysis was conducted on this data set in order to identify the variables that explained the majority of the variance. As shown in Table 6, the group the student was in accounts for 78% of the variance in the model, while rank and education explain 15% and 7% respectively. Combined, these three variables explain

	Standard deviation	Proportion of Variance	Cumulative Proportion
Group	32.1587715	0.7773859	0.7773859
Rank	13.9610838	0.1465130	0.9238988
Education	9.82459602	0.07255497	0.99645382
ESWS	1.969600738	0.002916045	0.999369860
Gender	0.7989040141	0.0004797632	0.9998496232
SeaTime	0.32548378437	0.00007963362	0.99992925684
PreTest	0.25071729527	0.00004725049	0.99997650733
Exposure Time	0.17678575526	0.00002349267	1.00000000000

Table 6. Variance as explained by Principal Components (May Class Data Set).

99.6% of the variance in the data. Of interest, this was the only instance where education was a significant factor in the linear model. Eight of 13 students (61.5%) in the May RPL class treatment group had earned college degrees. This, coupled with the fact that they volunteered to be in the treatment group most likely influenced the oral board scores, and would explain the appearance of education as a significant variable.

5. Hypothesis Testing

In order to determine or quantify the impact on preparing a candidate Repair Party Leader gained by using IDCTT (RPL), the hypotheses generated in Chapter IV.A.4 were tested. As stated in Chapter IV.B.2, the dependent variable was assumed to be Normally distributed, enabling the use of parametric methods for hypothesis testing. In order to satisfy the assumption of equal variance between control and treatment group oral board scores, the following hypothesis was evaluated, using a two-sided F-test:

H_o: The variances of the May class oral board scores recorded by the control and treatment group were equal.

versus

H_1: The variances were not equal.

The F-test yielded a test statistic of 0.8531 and a p-value of 0.7876. Based on a level of significance of 0.05, the null hypothesis could not be rejected. Therefore, for the purposes of this analysis, the variances of the control and treatment group oral board scores were assumed to be equal.

As discussed in Chapter V.A.4, a power function was developed for the May 97 data set. Figure 19 indicates that, as was the case with the complete data set, the test of hypothesis has greater ability to detect larger differences between mean control and

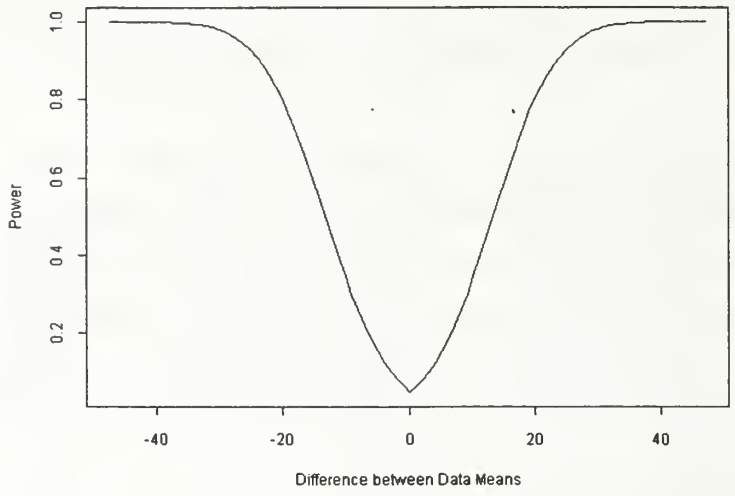


Figure 19. Power Function for May 97 Data Set.

treatment group oral board scores. This curve was developed using a range of hypothesized differences in control and treatment group means over the interval (-40, 40) due to the fact that the actual difference is 35.008. As Figure 19 shows, the power of the test to detect a difference between the means equal to 20 percent is approximately 0.80, while if the mean difference were 10 percent, the power of the test is reduced to approximately 25%.

To test the hypothesis that the control and treatment group oral board mean scores were equivalent, a two-sample *t* test was conducted. This test revealed that, at $\alpha = 0.05$, the null hypothesis was rejected (p-value = 0). In order to determine the true magnitude of the difference between control and treatment group mean oral board scores, the hypothesis was tested using an arbitrary value for the difference in the means. Since the

calculated difference is approximately 35, the value for the test was established arbitrarily at 42.5. When the null hypothesis is changed to test whether the difference between the treatment and control mean oral board scores is greater than 42.5, the null hypothesis is rejected, but with a much higher p-value (0.0487). The true treatment group mean (80.06) is significantly larger than the true control group mean (45.05538), indicating that for the May class, the use of IDCTT (RPL) may have had a significant impact on oral board performance.

6. Analysis of Results

Clearly, the May class treatment group performed better on the oral boards when compared with any other group in the study. The fact that IDCTT (RPL) exposure time was significant at the 10% level (p-value = 0.0623) is interesting in that this class was the only one where use of the system reflected any significant benefit to the students in the treatment group. Within the treatment group, it would appear that exposure to more than three IDCTT (RPL) sessions was important in the student's performance on the oral board. As shown in Figure 18, a student with more than 17 minutes of time using IDCTT would could be expected to score nearly 12 points higher on the oral board than one with less exposure. This data division is the only one tested that clearly indicates the benefit of increased system usage. Using volunteers as the treatment group may have compromised the validity of the experiment somewhat, but the results may provide a better indication of what can be expected in fleet application. The larger proportion of officers using the system in the May class also creates interesting questions regarding computer ability.

D. ANALYSIS OF CENSORED DATA SET

As mentioned in Chapter IV.B.1, additional variables were available for 52 participants of the study. The censored data set is provided in Appendix D. Subject race, Armed Forces Qualifying Test Score and Mental Category, as well as scores achieved on the various Armed Services Vocational Aptitude Battery subtests were provided by the

DMDC database. As such, this information was included in the analysis in order to determine variable influence on each subject's performance during the Oral Board administered at the conclusion of the Repair Party Leader course.

1. Variable Selection

Appendix E provides the results of stepwise regression on 13 independent variables using the "forward inclusion" method provided by S-Plus. As shown in Appendix E, the variables were added in the following order:

1. Race
2. Group
3. ESWS
4. Class
5. Pre-Test Score
6. Sea Duty Experience (SeaTime)
7. Rank
8. Mental Category (MenCat)
9. AFQT
10. Exposure Time
11. Education
12. Computer Aptitude Index
13. Gender

Figure 20 provides a graphical representation of the impact the addition of each variable has on the reduction in the residual sum of squares (numbers on the x-axis correspond to the independent variable listed above). As shown in Figure 20, the curve has a steep slope until the model contains six or seven variables, and then flattens out, indicating that the addition of variables eight through 13 do not provide a significant decrease in R^2. This result provides visual evidence that level of education, computer aptitude, gender or time spent working through scenarios using IDCTT (exposure time) did not noticeably influence the subject's performance on the Oral Board.

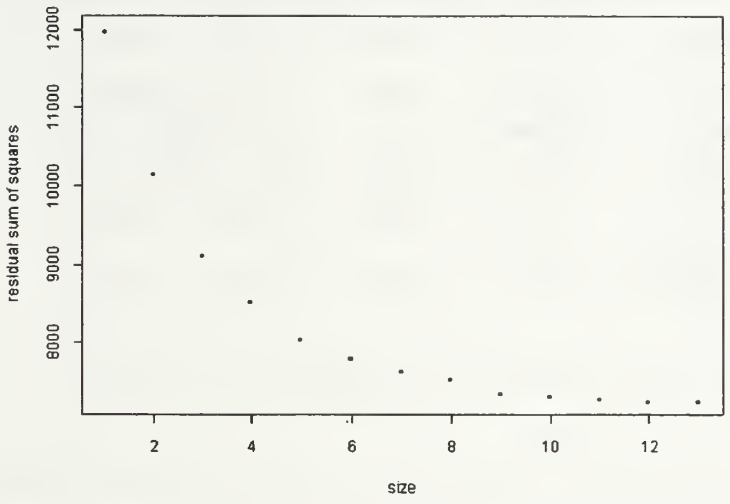


Figure 20. Variable Selection via Stepwise Regression.

2. Analysis of Variance

Using the results of the stepwise regression, ANOVA was conducted on a model employing the best six variables. Appendix F provides the results of analysis of variance of the six variable model, including interaction. As shown, this analysis indicated that race, group (i.e. control or treatment), ESWS qualification, class and pre-test score were significant predictors of a student's oral board score. Rank, while one of the variables identified during the stepwise regression as important, is an insignificant predictor of performance on the oral board as indicated by this model (p-value = 0.1289). The complicated interactions present between the variables are difficult to understand or interpret; therefore, these interactions will be disregarded for this analysis.

A linear model was developed using the results of the ANOVA to further explain the data. This model eliminates the contribution of rank, and renders the output presented in Table 7. This model provides an R^2 of 0.4175, indicating that 42% of the variance in this data is explained by these six variables. Of note, the score obtained by the student on the pre-test is a poor predictor of how that student will do on the end of course oral board. Additionally, the class the student was in is insignificant when examined in this context. This result will be shown to be of questionable value in later discussion. The linear model also confirms that pre-test score is an insignificant predictor of oral board performance.

	Value	Std. Error	t value	Pr(>|t|)
Intercept	30.9527	12.9658	2.3873	0.0211
Race	-7.6349	2.6019	-2.9344	0.0052
Group	10.4085	3.8609	2.6959	0.0098
ESWS	8.4458	3.8880	2.1723	0.0350
Class	4.2186	2.4236	1.7406	0.0884
Pre.TestScore	0.2577	0.1563	1.6491	0.1059

Table 7. Reduced (five variable) Linear Model (Censored Data).

Within-group variability was larger for the treatment group, suggesting there was an uneven distribution of achievement using IDCTT (RPL). Figure 21 shows that, while the median score attained by the treatment group was higher, this group also had slightly higher variability ($\sigma^2 = 344.83$ for the treatment group, $\sigma^2 = 161.44$ for the control group). The variance of the treatment and control group mean oral board scores are formally examined in section C.3 of this chapter.

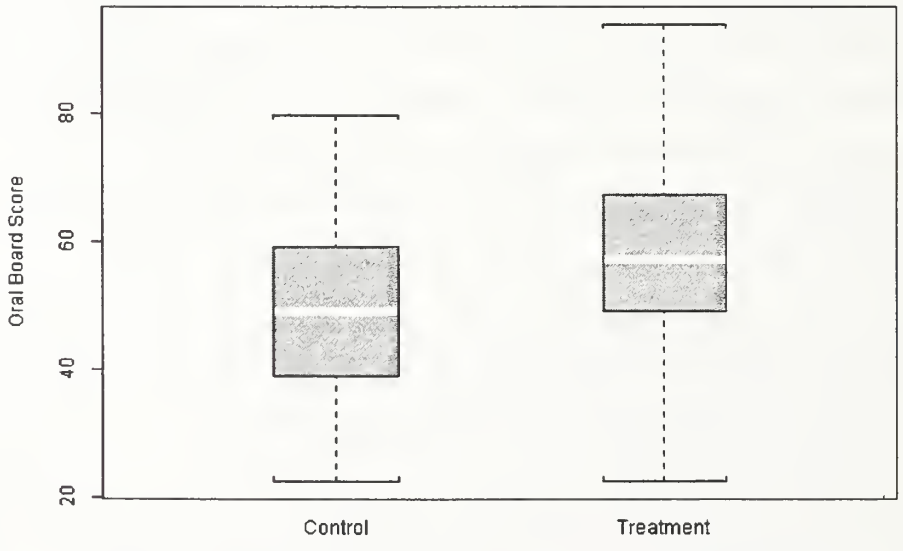


Figure 21. Boxplot of Control and Treatment Group Oral Board Scores.

The uneven distribution of achievement for the treatment group could be attributed to any one or all of the variables. Figure 22 examines four of these variables:

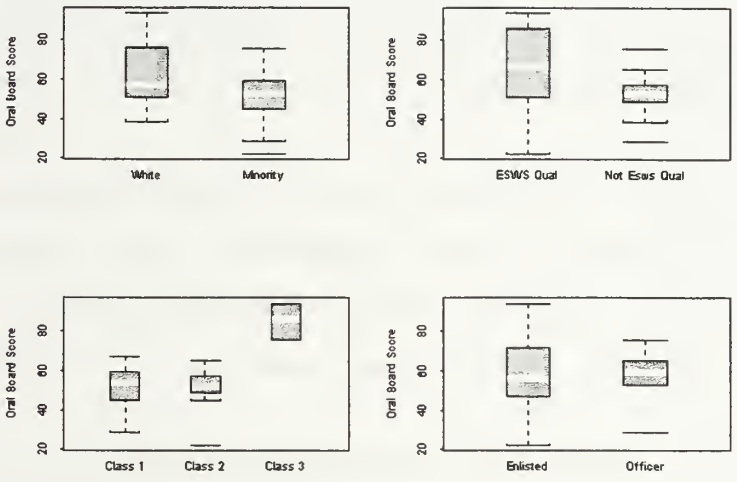


Figure 22. Boxplots of Treatment Group Variability.

ethnic group, advanced qualifications, class in which the subject was enrolled, and paygrade. These plots indicate that there was a visual difference in performance within the treatment group based on ethnic group, ESWS qualification and, most strikingly, the class the student attended. The evidence that class is significant contradicts earlier findings, but makes sense when the uncensored data is reviewed. Based on the boxplot in Figure 22, it does not appear very important whether the student was an officer or enlisted. These results generally support the findings of the previously conducted ANOVA.

3. Hypothesis Testing

The power function developed for the censored data set is presented as Figure 23. Since the actual difference between the control and treatment group mean oral board scores was 10.27314, the range of hypothesized differences was established at (-30, 30). In contrast to the previously shown power functions, the test in this case has power equal to approximately 0.65 when the hypothesized mean difference is equal to ten percent. This test is more powerful across the range of hypothesized differences, providing a

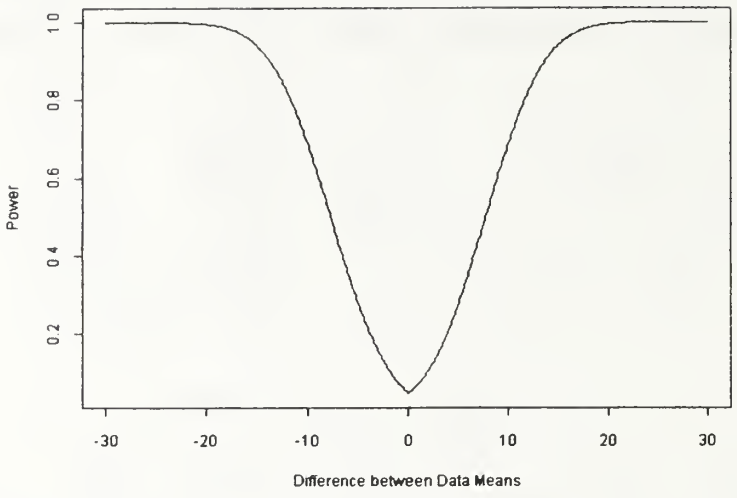


Figure 23. Power Function for Censored Data Set.

power equal to 1 at $\Delta \approx 15$ percent (where Δ is the difference between treatment and control group mean oral board scores), as opposed to values greater than 20 percent for the other data sets.

The issue remains to determine if use of the IDCTT (RPL) system enhanced the performance of the students on the oral board. Figure 24 provides some evidence that the treatment is effective, but the extent of the benefit of the IDCTT (RPL) in enhancing oral

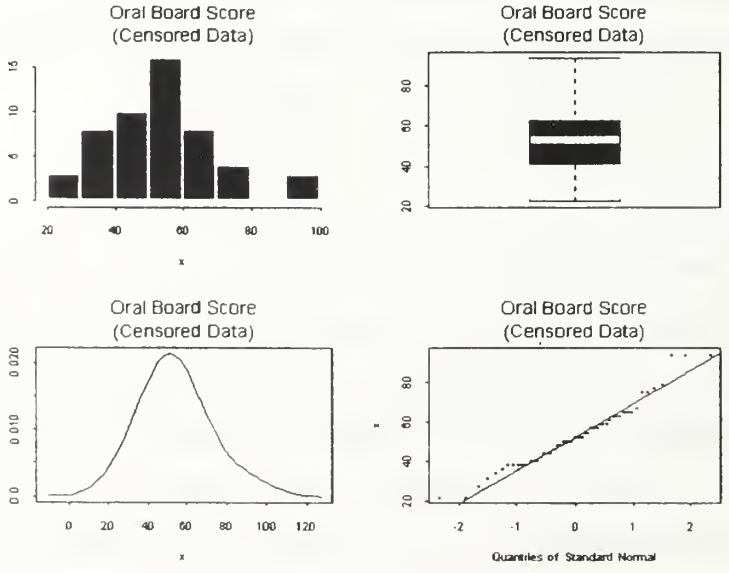


Figure 24. Diagnostic Plots for Censored Data Set.

board performance is unknown. The histogram and QQ-plot in Figure 24 indicate the near normality of the oral board scores recorded from the censored data set. The QQ-plot indicates, however, the presence of positive skew and the possibility of high outliers. Several transformations were attempted, but none produced results that appeared more normal, so the raw data was retained, and was assumed to be Normally distributed for analytical purposes.

Once the normality of the data had been established, a test for the equality of sample variance was in order. To determine whether the variance of the control and treatment group oral board scores were the same, the F-test was used to check the following hypothesis:

H_o: The variances of the censored data set oral board scores recorded by the control and treatment group were equal.

versus

H_1: The variances were not equal.

Under this procedure, an F-statistic of 2.1359 was produced, along with a p-value of 0.0615. Based on a level of significance equal to 0.05, the null hypothesis could not be rejected. Therefore, for the purposes of this analysis, the variances in question were assumed to be equal.

In order to determine the relative performance of the students in the treatment group relative to that of the control group, the following hypotheses were established:

H_o: The mean oral board score recorded by the control and treatment group were equal.

versus

H_1: The treatment group recorded a higher mean oral board score.

To test this hypothesis, a two-sample *t* test was conducted. This test indicated that at a level of significance of 0.05 and a *t*-statistic of 2.3434, there was a difference between the means (p-value = 0.0116) and the null hypothesis was rejected. In fact, the mean oral

board score of the control group was 48.83, while the treatment group recorded a mean of 59.10. As a result of the use of the IDCTT (RPL), the treatment group achieved a learning benefit of 21.03% over the control group, a finding that is consistent with improvements noted in other studies of the effectiveness of multimedia training systems when used in military applications (Fletcher, 1991).

4. Analysis of Results

Initially, it was thought that level of education and computer aptitude would have a noticeable impact on a student's ability to use the IDCTT (RPL), and, consequently on his or her performance during the post-treatment oral board. Clearly, this was not the case. In fact, education, and computer aptitude were eleventh and twelfth in importance as shown by stepwise regression. This result was counterintuitive. As one would expect, however, being in the treatment group was a significant factor contributing to the higher oral board scores, indicating that the students did receive benefit from exposure to the interactive multimedia learning system. The class the student was in was also significant, leading to the conclusion that either there were differences in the three learning groups (i.e. the volunteers in the May class performed better), or that the conduct of the oral board was inconsistent between classes convened in March and April and the class convened in May. Qualifications earned prior to attending the RPL course also had an effect on the result. A priori, it was thought that students who were Enlisted Surface Warfare Specialists or Surface Warfare-qualified officers would perform better on the oral board, regardless of the training track assigned. This was borne out by the results in that ESWS was a significant factor.

E. SUMMARY OF RESULTS

Table 8 provides summary information regarding the results obtained from this study, using the hypothesis listed below:

H_o: The mean oral board score recorded by the control and treatment group were equal.

versus

H_1: The treatment group recorded a higher mean oral board score.

Data	Significant Variables (ANOVA)	Result of Hypothesis Test	Mean OBS		Quantitative Learning Advantage
			Control	Treatment	
Complete Set	Group, Class,	Null rejected	48.47	60.78	20.26%
May 97 Class	Group	Null rejected	45.06	80.06	77.54%
Censored Set	Race, Group, ESWS, Class, PreTest	Null rejected	48.83	59.10	21.03%

Table 8. Results Summary.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The purpose of this thesis was to determine whether using IDCTT (RPL) as a supplemental learning tool would produce a Repair Party Leader School graduate that was closer to qualification than those students trained using the traditional schoolhouse method alone. As stated in Chapter V.A.4, the following hypothesis was tested to determine the impact use of IDCTT (RPL) had on the learning of students in RPL School:

H_o: The mean oral board score recorded by the control and treatment group were equal.

versus

H_1: The treatment group recorded a higher mean oral board score.

Based on the information contained in Table 8, it can be concluded that use of IDCTT (RPL) at the Repair Party Leader School in San Diego did have a positive impact on the oral board scores recorded by the treatment group. While the amount of advantage gained by the treatment group was fairly consistent between the complete data set and the members of the censored set, the huge advantage gained by the treatment group in the May class is noteworthy. Learning advantage may not be a good measure of progress along the curve of final qualification, but performance on the oral board provides an indication as to whether the RPL candidate possesses the basic knowledge expected of a Repair Party Leader aboard ship.

As previously mentioned the treatment group for the May class was comprised of volunteers. Review of literature presenting experiments of this type did not address the effect motivation would have on the results. Since the May class performed substantially better than the other two classes, it would appear that the motivated student is able to achieve greater benefit by using the system than a possibly resistant subject. Of course, it

could be hypothesized that the motivated student would perform better anyway, dampening the attribution of success to use of IDCTT (RPL).

It was surprising that previously attained advanced qualifications (ESWS), rank and education (including computer aptitude) were not found to be significant factors in this research. This lack of significance would lead to the belief that IDCTT (RPL) is a very user-friendly system, one that makes it easy for the student to proceed through the scenario, gaining experience along the way. Additionally, it could be stated that when coupled with a rigorous training program (like RPL School), the level of qualification previously held by the student is not as important as might have been assumed. This is a positive aspect of this interactive system in that its employment in the fleet will be to train Sailors of all ranks, rates and levels of experience.

B. RECOMMENDATIONS FOR IDCTT (RPL) IMPROVEMENT

IDCTT (RPL) is a very easy system to use, and the computer on which the software was installed was fast and capable. However, the limited number of scenarios may accelerate the student's loss of interest in conducting the number of repetitions required to become a proficient Repair Party Leader. The following are recommendations for IDCTT (RPL) improvement.

1. Improve the feedback system.

Currently, the post-scenario feedback provided to the student consists of a brief pass/fail assessment of performance, followed by a review of actions taken by the user. This could be embellished by designing the system to reinforce actions taken correctly, as well as pointing out procedural errors, steps taken out of sequence and errors made due to lack of knowledge regarding ship's systems. A major portion of the debrief/critique presented at the conclusion of an actual damage control drill addresses what the Repair Locker did correctly, as well as presenting discrepancies. An enhancement of the feedback system would allow either supervisory personnel or the motivated user to tailor a training package to address shortcomings discovered during the scenario. For greatest

impact, IDCTT (RPL) could provide a printed report of errors, the action that should have been taken, and the reference for the step.

2. Simplify the process required to locally develop scenarios.

Scenarios available today are provided by the prime software contractor. Making it possible for the shipboard damage control organization to locally generate scenarios would be a noteworthy enhancement in utility of the system aboard ship. The ability to build and test scenarios would provide at least two benefits. First, the ship would be able to provide tailored training to its Repair Locker Leaders. Second, the Damage Control Training Team would be able to prepare scenarios for live drills, and then test them for pitfalls prior to actually placing ship's company at General Quarters and executing the drill plan. This would decrease time spent developing quality drills, and would enhance the amount of benefit damage control personnel would gain per hour spent at General Quarters. A well-designed drill makes a big difference in the training received by the crew.

3. Add a tutorial package to the existing software.

Alessi and Trollip (1991) describe training as a four-part process. In its current configuration, IDCTT (RPL) does not address the aspect of "presenting the information" to the student. Addition of an in-depth tutorial covering advanced damage control theory and procedures is necessary in order to increase the training ability of the system. Ideally, students would be able to select a training package covering a particular aspect of damage control, and, after taking the tutorial, immediately apply the material in the tutorial to a scenario selected from the menu. This rapid use of knowledge would serve to reinforce what has been learned, increasing the amount retained by the user.

4. Add an on-line library.

A noteworthy shortcoming of IDCTT (RPL) in its current configuration is the lack of an on-line library of damage control publications. While many actions required of the RPL should be committed to memory, many others allow for thought and review of

information. In a shipboard repair locker, the RPL has access to many sources of information, including a large library of pertinent damage control publications. By being able to access these during a scenario, the training environment would be more realistic, and would also familiarize the RPL with reference assets contained in his or her repair locker.

5. Provide scenarios for other ship classes.

Currently, IDCTT (RPL) scenarios exist only for DDG-51 class ships. While this class of ship comprises a significant portion of the Navy's surface combatants, there are numerous other classes that are underrepresented. In order to enhance the fleet-wide utility of IDCTT (RPL), scenarios based aboard cruisers, guided missile frigates, amphibious and combat logistics force ships should be developed as soon as possible.

C. RECOMMENDATIONS FOR FURTHER RESEARCH

This study provides evidence that using IDCTT (RPL) as an educational augment to the traditional Repair Party Leader School curriculum would be of benefit to the students enrolled in the course. There are, however, several additional areas of research that could be pursued in order to validate the findings of this study.

1. Improve the experimental design.

In order to provide a better measure of effectiveness for IDCTT (RPL) as tested at the Repair Party Leader School, the pretest should take the form of an oral board comprised of questions similar to those asked at the end of the course. This change would provide a better indication of entrance level of knowledge pertinent to the type of learning that would be expected to be delivered by IDCTT (RPL). As conducted, it was difficult to relate pre-test scores and oral board results.

2. Other research opportunities.

Aside from ensuring that the Repair Party Leader is fully competent at the completion of the qualification process, the most important factor is the amount of time required to achieve shipboard RPL certification. Other studies, including Army-sponsored research regarding the training of communications specialists (Winkler and Polich, 1991), report that interactive training systems significantly reduce the time required for a trainee to develop a skill. If students attending RPL School were identified, trained with IDCTT (RPL) as a supplement to traditional training, and tracked to completion of qualification aboard ship, the time required to complete this process could be compared with those not receiving IDCTT (RPL) training. This information could be used as support for a cost-benefit study on which to base procurement and system fielding decisions. Finally, an additional study could be commissioned to determine whether the effect was due to instruction or could be attributed directly to use of the IDCTT (RPL). While the result of this research is encouraging with respect to the prospect of using interactive methods to train Repair Party Leaders, it is still not clear what the difference will be when used in fleet applications. A study conducted aboard ship, comparing the actual performance of school graduate RPL's with those trained using only IDCTT (RPL) would provide additional information relative to the system's effectiveness.

APPENDIX A. IDCTT (RPL) TEACHING POINTS

Dr. Eric Allely of Tekamah Company provided these teaching points. Tekamah develops the source code for all scenarios used in IDCTT (RPL). The listed teaching points were current as of March, 1997.

Teaching Point Pitfall: action not taken

1. Report Repair 3 Manned and Ready

   The Manned and Ready report signifies that personnel are available to combat casualties and are prepared with proper equipment, personnel protection and communications. It is imperative that the senior person in the Repair Station provides the report to DC Central as soon as personnel are ready to commence fighting the casualty. (NWP62-1D)

   Manned and Ready time requirements are contained in FXP-4 exercise MOB-D-3-SF. For a DD/DDG class ship the time standard for Manned and Ready is 5 minutes.

2. Zebra set.

   Material Condition zebra provides the greatest degree of subdivision and watertight integrity to the ship. It is the maximum state of readiness.

   In FXP-4 exercise MOB-D-11-SF, the time standard for setting material condition zebra for a DD/ DDG class ship is 5 minutes

3. Modified Zebra

   Certain situation may require the CO to order material condition modified zebra set. Modified material condition zebra will give a higher survivability stance than condition yoke, while modified zebra is less restrictive and will allow the accomplishment of certain operational requirements.(DC PQS)

4. Changing material condition (Y, W, circle W)

   Changes in the ship's material condition require Commanding Officer approval (NWP 3-20.31)

5. Investigation

   Investigation teams should be rapidly dispatched. Any delays in investigating damage may result in the further progressive spread of damage. Investigation shall be thorough, conducted with caution, clearly and quickly reported and investigation is to be repeated (DC PQS)

6. Flooding Boundaries

The setting of flooding boundaries should be an immediate action when flooding is reported to limit progressive flooding into adjacent compartments.

Flooding boundaries should be set at the main transverse watertight bulkheads closest to the flooding. (DC PQS)

7. Fire Main valve isolation

Rapid firemain valve isolation will reduce flooding from ruptured piping. Firemain isolation should be coordinated with DC Central to prevent disruption to vital systems served by the firemain.

8. Hole patched

Failure to patch a hole in the bulkhead will result in progressive flooding into adjacent compartments.

9. Progressive flooding

10. Shore Bulkhead

Failure to shore a panting bulkhead may result in the loss of the bulkhead and damage to the adjacent compartment.

Indications of the need for shoring include deep bulges in plating, bowed frames and stanchions, loose rivets, cracked seams, and panting bulkheads. Panting is a dangerous condition. It results in metal fatigue. Which eventually causes cracking and splitting. (Repair Party Manual)

When in doubt always shore! (Repair Party Manual)

11. Request additional personnel for Flooding

Requests for additional personnel should be coordinated via Damage Control Central. A failure to keep DC Central informed and to coordinate limited Damage Control resources may result in repair teams being overwhelmed by cascading casualties.

12. Request route

Routing of personnel transiting the Repair Station area should be coordinated with DC Central.

13. Stability is Critical

The "Basic Thumbrules of Critical Stability" are contained in the CNSL/CNSP Repair Party Manual. All Repair Party Leaders should be familiar with basic stability concepts. In some circumstances, particularly when inport, an RPL may be the only person onboard with training in stability principles.

Stability may be is critical if any of the following conditions exist following damage:

Small or negative metacentric height
exceeding floodable length
excessive list
heavy winds and seas

Small or NegativeMetacentric Height
When stability is critical due to small or negative metacentric height:

a. The ship is logy with a slow erratic roll period and a tendency to hang at the end of the roll.
b. The ship has a tendency to list at the same angle to either side.
c. The ship has a list which cannot be accounted for by off-center weight. (Repair Party Manual)

Exceeding Floodable Length
When Stability is critical due to exceeding floodable length, the extent of flooding approaches or exceeds the maximum amount of flooding tabulated in the ships Damage Control Book, section II (a) (Repair Party Manual)

Excessive List
When Stability is critical due to excessive list, the ship lists to a static heel of 15 degrees or more. (Repair Party Manual)

Heavy Winds and Seas
When Stability is critical due to heavy winds and seas, Heavy winds and rough seas are prevailing or are anticipated. (Repair Party Manual)

14. Counterflooding or Ballasting

Counterflooding or Ballasting requires the approval of the Commanding Officer (NWP 3-20.31)

15. Jettisoning

Jettisoning requires the approval of the Commanding Officer (NWP 3-20.31)

16. Starting/Stopping Firepumps

Firemain management requires close coordination with DC Central. The starting and stopping of fire pumps should be ordered by DC Central.

17. Dewater using installed Eductor (No FM)

Installed eductors require proper firemain pressure to operate. Improper alignment of the ship's firemain system when using eductors may result in accidental flooding rather than dewatering of a compartment.

18. Fire Boundaries

Any physical barrier can be a fire boundary. Ideally fire boundaries are the bulkheads, deck, and overhead surrounding the fire. Secondary boundaries are generally set at watertight subdivisions or airtight boundaries. (NWP 62-1D)

19. Smoke Boundaries

Smoke boundaries are set to contain smoke within a fixed area and prevent the spread of smoke either horizontally or vertically. (NWP 62-1D)

20. Failure to Request additional personnel for F/F

Rapidly manning fire teams may be difficult if other Damage Control procedures are already in progress and repair personnel have been assigned to other teams. Emerging fire team requirements should be coordinated with DC Central to ensure the fastest response and prevent fires from rapidly spreading.

21. Electrical Isolation

The extent of compartment electrical isolation and the securing of lighting is typically determined by the scene leader.(NSTM 555)

22. Mechanical Isolation

When a space is abandoned due to fire, the space should be mechanically and electrically isolated to the greatest extent possible. A CO may choose not to isolate such spaces if they are essential to the safety, mobility, or fighting capability of the ship (NSTM 555).

23. Securing of ventilation

The decision to secure ventilation systems is made on scene.(NWP 62-1D)

24. Magazine Sprinkler activation

Activation of magazine sprinklers requires the approval of the Commanding Officer. (NWP 3-20.31)

25. Magazine sprinklers activation, no FM

Firemain management requires attention to vital systems served by the firemain including magazine sprinkler systems.

26. Movement of Ammunition

The movement of ammunition onboard the ship requires approval from the Commanding Officer. Ammunition movement should be conducted by trained Combat Systems personnel and should be coordinated via DC Central and Combat Systems Maintenance Central.

27. Halon activation

Halon activation may prove ineffective if the compartment has been sufficiently damaged to prevent Halon from reaching the proper concentration in the space to extinguish the fire.

28. Jettison of ammunition

The jettisoning of objects over the side requires Commanding Officer approval. (NWP 3-20.31) The movement of ammunition (including moving it over the side) also requires Commanding Officer approval.

29. Jettison of Gas Cylinders

The jettisoning of objects over the side requires CO approval. (NWP 3-20.31)
Evacuation of Repair 3 (smoke)

The evacuation of personnel within the Repair Station area to the weatherdecks may be required when smoke boundaries are not correctly ordered and set.

30. Direct Attack

In a direct attack, firefighters advance into the immediate fire area and apply the extinguishing agent directly onto the seat of the fire. (NSTM 555)

31. Indirect Attack

An indirect attack is the application of water fog into the fire space through an existing access or through a hole cut in a bulkhead or overhead when heat or other conditions deny access to the space, an indirect attack may improve condition conditions to permit reentry for a direct attack.. (NSTM 555)

32. Active Desmoking

Active desmoking is removing smoke and heat from the smoke control zone prior to extinguishing the fire, to aid firefighting efforts and reduce smoke spread in the ship. (NSTM 555)

33. Overhaul of Fire

Overhaul of a fire is an examination and cleanup operation. It includes finding and extinguishing hidden fires and determining whether the fire has extended to other areas of the ship. (NSTM 555)

34. Desmoke

After a compartment fire has been extinguished, combustible gases may be present. The goal of desmoking is to replace 95% of the smoke laden air with fresh air. This will require approximately 4 complete space volume changes in the compartment. (NSTM 555)

35. Atmospheric Testing

All spaces should be desmoked before atmospheric testing is started because oxygen sensors do not operate reliably if the sensor is exposed to excessive moisture or is in contact with postfire atmospheric particulates.

36. Request Personnel Casualty Transport Route

FXP-4 exercise FSO-M-2-SF states that a safe route for stretcher-bearers should be received from DC Central. The FXP-4 time standard for stretcher- bearers to arrive on scene is within 10 minutes of the casualty report.

37. Manning Flight Quarters

Due to damage control actions already in progress in the Repair 3 area, manning the Aviation Crash and Salvage Team exclusively from Repair 3 may result in Repair team manning shortfalls. As RPL you should inform DC Central of anticipated problems and request additional personnel when necessary.

38. Hazardous Material Incident Response

Any material that because of its quantity, concentration, or physical or chemical characteristics may pose a substantial hazard to human health or the environment when released or spilled. (DC PQS)

39. Casualty Power

The engineering officer will designate the switchboard and riser to be used as a source of casualty power. (Repair Party Manual)

The casualty power route should be requested from DC Central.

Permission to rig casualty power should be requested from DC Central.

40. MOPP Levels

Changes to the MOPP level should be directed by DC Central and the Commanding Officer.

41. Counter Measure Washdown System

Activation of the counter measure washdown system (CMWDS) requires the approval of the ships Commanding Officer. (NWP 62-1D)

42. Dispatching External CBR Monitors

Dispatching external CBR monitors outside the skin of the ship when in a CBR environment requires the Commanding Officer's approval (Repair Party Manual)

43. Dispatching External CBR Decontamination Teams

Dispatching External CBR Decontamination Teams outside the skin of the ship when in a CBR environment requires the Commanding Officer's approval (Repair Party Manual)

APPENDIX B STUDENT ENTRANCE DATA SHEET AND PRE-TEST

This appendix provides the pre-test administered to students in the March, April and May 1997 Repair Party Leader School at Fleet Training Center, San Diego California. The first page of this examination provided the vehicle for collection of demographic data on each participating student.

REPAIR PARTY LEADER COURSE PRE-TEST

INSTRUCTIONS FOR TAKING TEST

READ CAREFULLY

1. **Purpose of the Test**. This pre-test is given in support of research that is being done regarding the possible incorporation of interactive courseware in the training process at this school. Your participation in this study is purely voluntary, but you may have fun and really learn something! This test is given in order to determine the baseline level of knowledge each student has upon enrolling in the course. Your score on this exam will have no impact on the remainder of the course. The questions for this test will be multiple choice, true-false, and fill-in. Circle the correct answer or fill in the blank as required.

2. Quickly fill in the information requested on the attached information sheet.

3. If you need assistance during the test, raise your hand. One of the instructors will assist you.

4. Examples

A. MULTIPLE CHOICE AND FILL-IN

Each question has four choices; a, b, c, and d. Read all four choices carefully. Only one answer will be correct.

B. TRUE-FALSE

If any part of the statement is false, the whole item is to be marked false on the test. True statements are to be marked by circling 'True' on the test sheet. For false statements, circle 'False'.

5. 20 minutes is allotted for this test. When you have completed the test, remain quiet at your seat until told to turn in your test.

6. CAUTION

If you desire to change an answer, erase your first choice completely, then select your new choice. ANY CHOICE HAVING TWO OR MORE ANSWERS SELECTED IS AUTOMATICALLY CONSIDERED WRONG. ANSWER EVERY QUESTION. IF YOU UNDERSTAND THE INSTRUCTIONS, WAIT FOR THE SIGNAL, AND THEN BEGIN THE TEST.

STUDENT INFORMATION SHEET

REPAIR PARTY LEADER COURSE

Date _____ 1997

Name _____ Rank/Rate _____ ESWS Y N
(circle one)

SSN _____ Command _____
(name and hull number)

Date Reported to Present Command (Month/Year) _____

How much total sea time have you accumulated? _____ years _____months

Where do you go now for GQ?_____

What is your job there? _____

Have you ever attended

General Shipboard Firefighting School	Y N
Advanced Shipboard Firefighting School	Y N
DCPO School	Y N
Buttercup Wet Trainer	Y N

1. Fires on ships underway that have no at-sea fire party will normally be handled by the

   a. duty section.
   b. in-port fire party.
   c. repair party personnel.
   d. Naval Station fire protection personnel. 1.1.1

2. The Repair Party Leader's duties and responsibilities include

   a. establishing maximum permissible exposure (MPE).
   b. ordering the activation/deactivation of the water wash down system (WWDS).
   c. ordering the flooding of magazines.
   d. assigning repair party personnel to teams. 1.1.2

3. Part II of the Ship's Damage Control book contains

   a. general information.
   b. damage control systems.

c. miscellaneous systems.
d. electrical systems. 1.2.1

4. Heavy lines on isometric damage control diagrams indicate _____ boundaries.

a. water-tight and oil-tight
b. air-tight
c. fire retardant and flame-tight
d. non-tight 1.2.1

5. A DC training simulation of black cloth taped over an item would indicate _____.

a. black smoke.
b. spilled oil.
c. charring.
d. class "B" fire. 1.3.1.1

For items 6 through 9, match the advantages/limitations in Column A to the DC communications systems in Column B by drawing a line between the two.

COLUMN A	COLUMN B
6. A flexible and survivable means of rapid communications but can not be used in a weapons handling incident/ accident.	a. Intercommunication system.
7. Requires no external source of power.	b. DC WIFCOM.
8. Provides a fast and dependable two way transmission between DCC and each system repair station.	c. Ship's service telephones (J-circuit)
9. Not rugged, may go out of commission early in action, (requires electrical power).	d. Sound-powered telephone

10. Select the priority use of communications from DCC to the repair lockers.

a. 3, 1, 2 and 4.
b. 1, 3, 2 and 4..
c. 3, 2, 4 and 1
d. 1, 3, 4 and 2

1. DC Wifcom
2. MC Circuit.
3. Sound Powered Telephones.
4. Ship's Service Telephone, (J-circuit).

11. Isometric DC Diagrams, Status Boards, and Logs

a. are all unclassified documents.
b. require constant updating and close attention.
c. seldom require updating.
d. are only located on the bridge and in DCC.

12. A proper wedge has a length of ___ times its butt thickness.

a. 3
b. 6
c. 8
d. 10

13. Select the first step for by-passing a rupture in the firemain.

a. Rig one 2 1/2 inch hose from the two nearest pressurized sections beyond the rupture.
b. Remove the wye-gate from the required fireplugs.
c. Isolate the ruptured section.
d. Shut down the fireplug nearest the rupture.

14. The maximum length of a shore can not be more than ___ times it's minimum thickness.

a. 10
b. 20
c. 30
d. 40

15. An electric submersible pump will discharge ___ GPM with a 70 foot static head.

a. 140
b. 160
c. 200
d. 250

16. The permanent angle of heel taken by a ship due to flooding is called _____ .

a. roll
b. trim
c. pitch
d. list

17. The secondary drainage system _____

a. drains spaces forward and aft of the main machinery compartments.
b. has larger piping than the main drainage system.
c. is connected to and uses the same pumps and eductors as the main drainage system.
d. drains the main machinery compartments.

18. The firemain provides operating pressure to eductors in the _____ systems.

a. main and secondary drainage
b. supply and exhaust
c. primary and alternate
d. auxiliary firemain

19. For desmoking after a fire, installed or fixed ventilation systems can

a. never be used.
b. be used with the repair party leaders permission.
c. be used with restrictions.
d. be used if the exhaust discharges into a different space.

20. The Ram Fan 2000 is driven by .

a. LP air
b. Water under pressure
c. 110 VAC
d. HP air

21. Extra casualty power cables are stored in DC repair lockers in lengths of_____ feet.

a. 100
b. 150
c. 200
d. 250

22. The function of the Casualty Power System is to _____.

a. provide power to all weapon systems.
b. supply power to all of the ships electrical equipment.
c. make temporary power connections to vital systems/equipment.
d. splice and repair permanently damaged electrical components.

23. What is the correct sequence to be followed when rigging casualty power cable?

a. Rig power source to load
b. Rig from load to power source
c. No preferred sequence
d. From switchboard to power panel

24. An itemized list of all damage control equipment located in a compartment is called a/an _____.

a. Damage Control Book.
b. Closure Log.
c. Compartment Check-Off List, (CCOL).
d. EOSS.

MATCH THE COMPLETED DAMAGE CONTROL MESSAGE TO THE CORRESPONDING LETTER CODE THAT CORRECTLY IDENTIFIES THE MESSAGE.

25. Message No. 1

a. Un-jammed WTH 2-35-2 in compartment 2-23-0-L.
b. Un-jammed quick acting scuttle 2-35-2 in compartment 2-23-0-L.
c. Jammed WTH 2-35-2 in compartment 2-23-0-L.
d. Un-jammed quick acting WTH 2-35-2 in compartment 2-23-0-L.

26. Message No. 2

a. Electrical power lost in compartment 3-23-0-E.
b. Secured communications to compartment 3-23-0-E.
c. Electrical power ordered secured to compartment 3-23-0-E.
d. Restored communications to compartment 3-23-0-E.

27. Message No. 3

a. Minus oxygen, plus toxic gases in compartment 3-23-0-E.
b. Plus oxygen, plus explosive gases and plus toxic gases in compartment 3-23-0-E.
c. Plus oxygen, minus explosive gases and minus toxic gases in compartment 3-23-0-E.
d. Plus oxygen, minus toxic gases in compartment 3-23-0-E.

28. Message No. 4

a. Watertight hatch 3-36-2 is shored and shoring watch is set in compartment 3-23-0-E.

b. Watertight door 3-36-2 is reported shored in compartment 3-23-0-E.
c. Watertight hatch 3-36-2 is sprung and shoring watch is set in compartment 3-23-0-E.
d. Watertight hatch 3-36-2 in compartment 3-23-0-E is reported damaged.

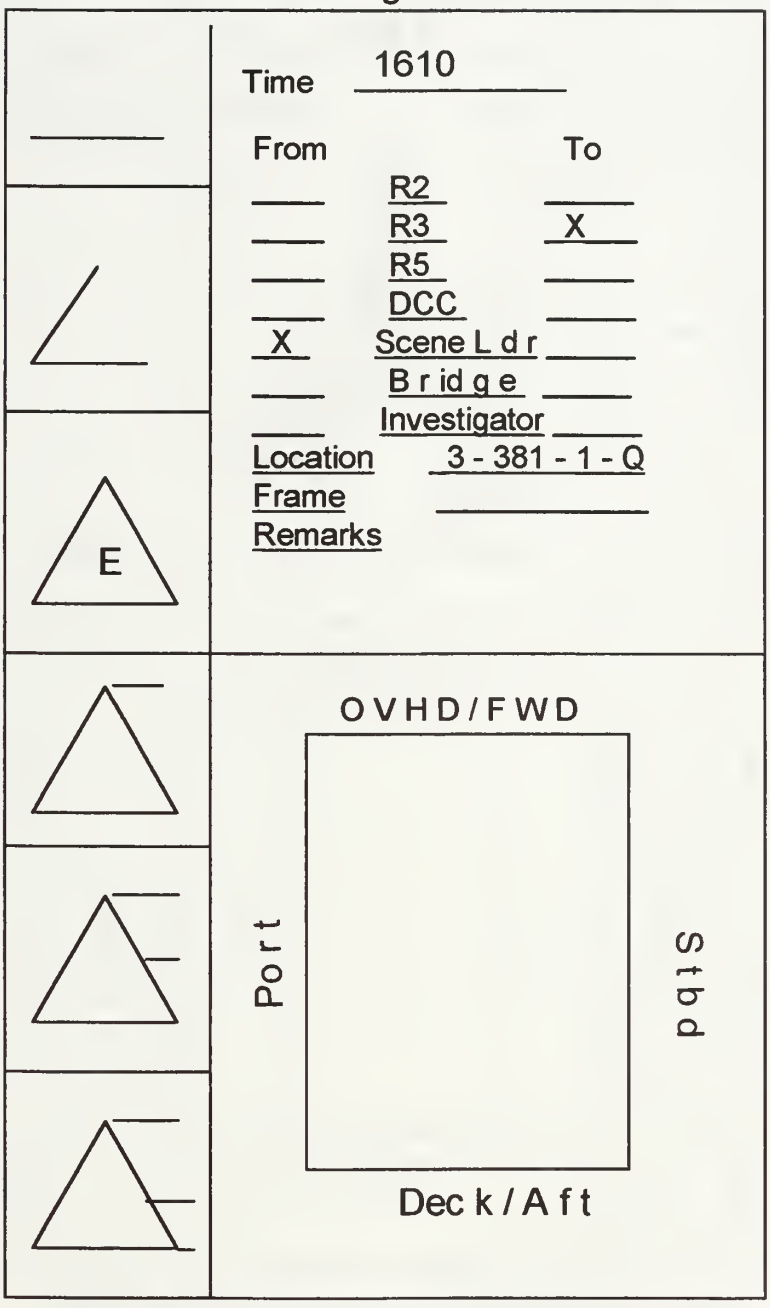
29. Message No. 5

a. Jammed watertight hatch 2-36-2 in compartment 2-24-0-L.
b. Un-jammed WTH 2-35-2 in compartment 2-23-0-L.
c. Jammed watertight hatch 2-35-2 in compartment 2-23-0-L.
d. Un-jammed watertight door 2-36-2 in compartment 2-24-0-L.

30. Message No. 6

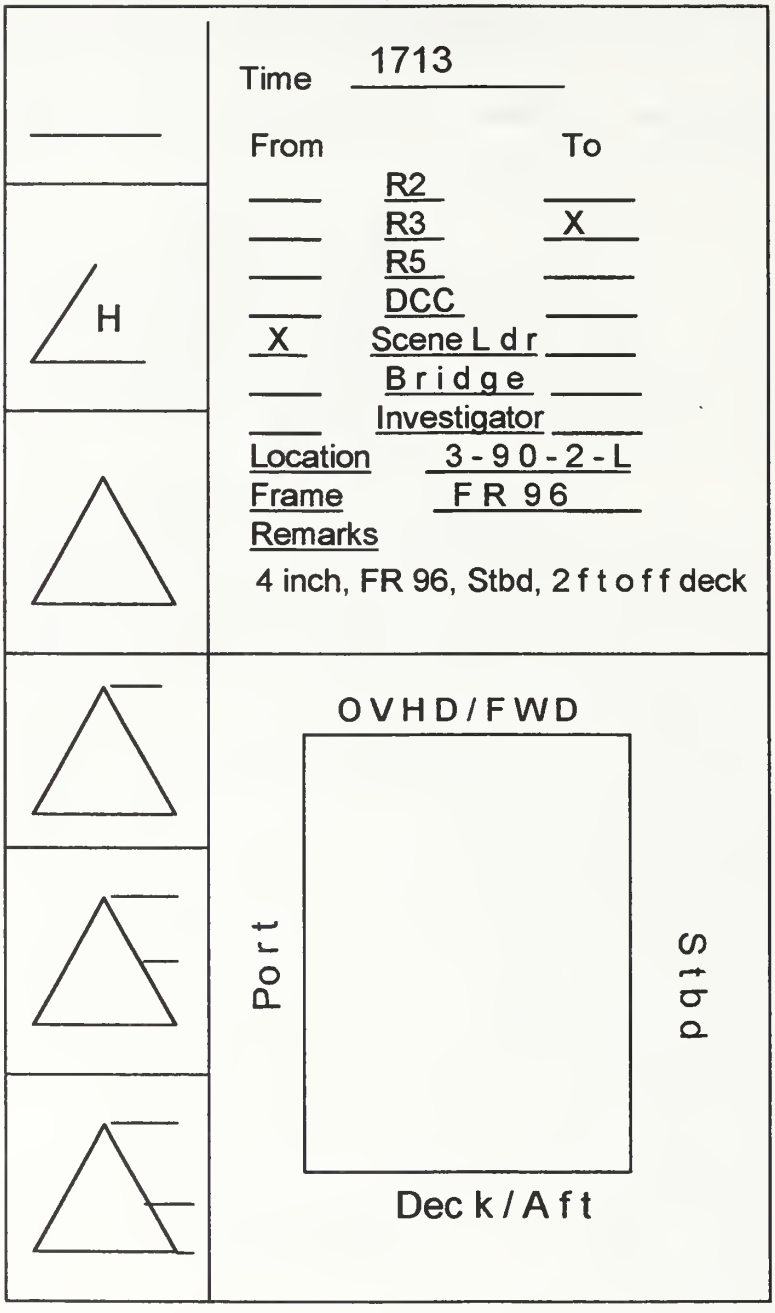
a. Ruptured firemain riser reported in compartment 2-15-1-L.
b. Ruptured firemain riser is repaired in compartment 2-15-1-L.
c. Desmoking completed in compartment 2-15-1-L.
d. Restored flooding boundaries in compartment 2-15-1-L.

Message Nr 1



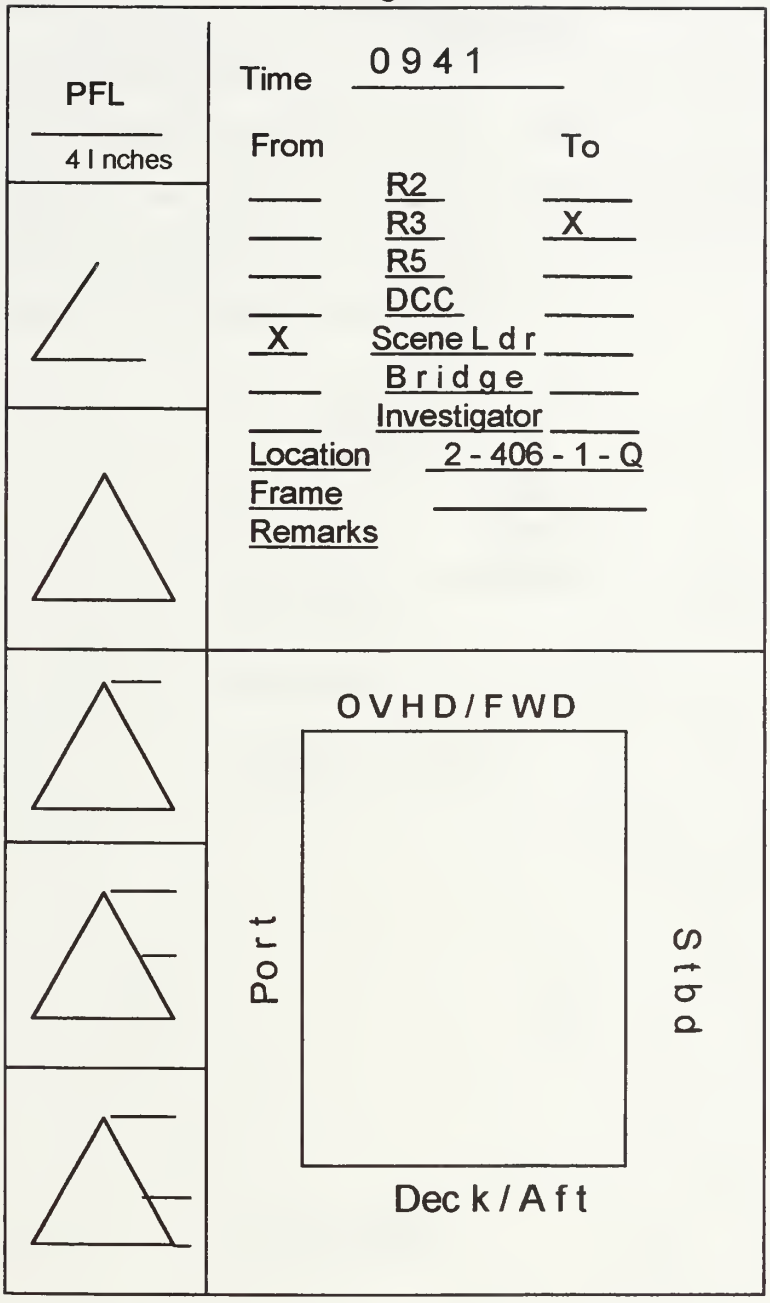
NWP 3-20.31, Figure 4.3, Sheet 9

Message Nr 2



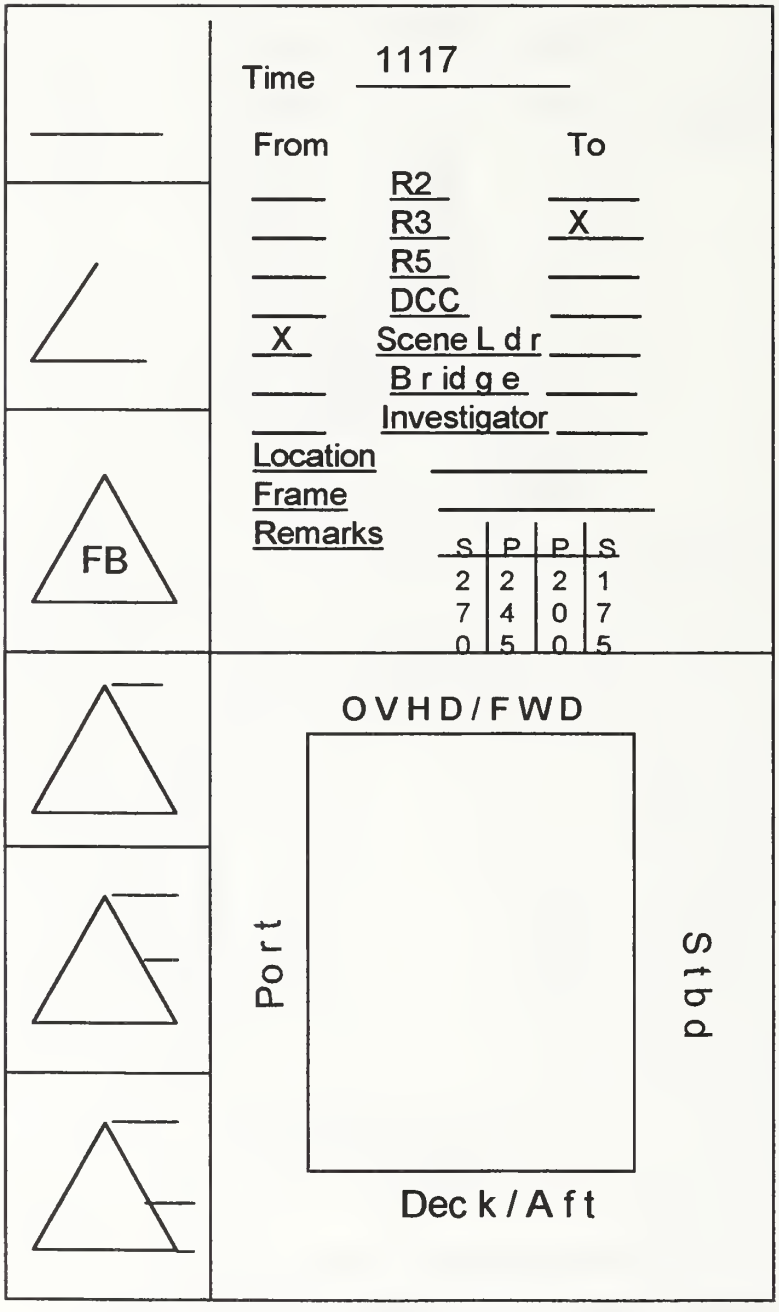
NWP 3-20.31, Figure 4.3, Sheet 13

Message Nr 3



NWP 3 - 20 . 31, Fi gure 4 . 3, Sheet 9

Message Nr 4



NWP 3 - 20 . 31, Figure 4 . 3, Sheet 1

APPENDIX C ORAL BOARD QUESTIONS AND PROCTOR INSTRUCTIONS

This appendix provides the instructions given to proctors administering the end-of-course oral boards, as well as questions to be asked verbatim. For most of the oral board questions, the applicable line item from NAVEDTRA 43119-G, Watchstation 318 (Repair Party Leader) has been identified. The question is designed to determine the individual's knowledge regarding that particular line item of the PQS.

Instructions to Oral Board Proctor

The purpose of this oral board is to provide a post-test to students of the Repair Party Course that may assist in determining the value of the IDCTT (RPL) as a system with which to augment damage control training delivered in the schoolhouse. The following instructions must be followed explicitly in order to ensure quality and validity of data collected.

Read the following paragraph to the student.

"The purpose of this oral board is to gather data that will help in determining the value of the interactive courseware that has been installed here at FTC. This board will have no impact on your final grade here at the school. I will now go over the method I will use for conducting this board.

1. You are to relax...remember, this board doesn't count toward your score in the course.
2. Do your best to answer each question. Think about your answer before giving it.
3. This board will last about 15 minutes. I will ask you a question every minute, on the minute. If you are still answering the previous question, I will stop you and we will move to the next question.
4. During the board, I will answer no questions and will not provide any information other than the question.

Before we begin, do you have any questions? If not, we'll start the board."

Reminders for the Proctor

1. Do not ask the student if he/she was in the group that used IDCTT.

2. Do not let the student see you writing your observations (i.e. don't jump on a response and make a production out of recording it)
3. Ask the questions at exactly 1 minute intervals. If the student answers the previous question early, wait until 1 minute has elapsed, then ask the next question. If the student is in the middle of an answer at the end of the 1 minute period, stop him/her and ask the next question.
4. Record the student's correct responses by placing checks in the blocks corresponding to the response. You have the authority to interpret the answer given in order to decide if it is correct (i.e. it is understood that the student will probably not quote the reference verbatim).
5. Do not enhance/embellish the question. These questions are scripted and must be read verbatim to each student.
6. Use a new sheet for each student. Ensure you record the student's SSN on the sheet prior to starting the board.
7. **It is most critical that the boards be consistent from one student to the next.**

Repair Party Leader

Oral Board Questions

Student Name _____ Board Date _____

SSN _____

NAVEDTRA 43119-G	Topic	Task
318.2.19	Maintain communications with DC Central and other Repair Stations.	Say steps of procedure

Question. You are Repair II Locker Leader. By ship's instruction, your locker is next in succession for control if something happens to DC Central. How will you ensure good communications and control of the ship-wide DC situation?

Answer. (Reference NSTM 079V2, 079.38.173)

1. _____ Conduct periodic communications checks with DCC.
2. _____ Maintain a plot of damage in <u>all</u> areas of the ship.
3. _____ Take positive control if DC Central is out of action.

NAVEDTRA 43119- G	Topic	Task
318.2.12	Coordinate Repair Party efforts to combat/control flooding.	Say steps of procedure

Question. List the actions the Repair Party Leader would take if flooding were reported in his/her area of responsibility.

Answer. (Reference CNSLINST 3541.1C/CNSPINST 3541.4B)

1. _____ Establish flooding boundaries.
2. _____ Electrically isolate the affected space.
3. _____ Mechanically isolate the affected space.
4. _____ Prioritize dewatering efforts.
5. _____ Evaluate the stability situation.

Question. What does this message tell you as Repair Party Leader? (<u>Show Message Blank Nr 1</u>)

Answer. (Reference NWP 3-20.31, Figure 4.3, sheet 9)

_____ Message Nr 1 says electrical power isolated in compartment 3-381-1-Q

Question. What are the minimum responsibilities of the Repair Party Leader in the event of fire in his/her area of responsibility.

Answer. (Reference NWP 3-20.31, Chapter 9.2.1.1)

1. _____ Ensure boundaries are established.
2. _____ Coordinate efforts to prevent vertical fire spread.
3. _____ Provide logistic support to the scene (personnel and equipment)
4. _____ Maintain an accurate plot.
5. _____ Make required status reports.

Question. List all the damage control actions for which you would need to get permission prior to doing.

Answer. (Reference Repair Party Manual, Chapter 1, Art 102, NWP 3-20.31, Art 1.5.8)

1. _____ Ballasting/deballasting
2. _____ Counter flooding
3. _____ Changes to established material condition of readiness
4. _____ Flooding weapons magazines
5. _____ Desmoking using installed ventilation

Question. What does this message tell you as Repair Party Leader? (Show Message Blank Nr 2)

Answer. (Reference NWP 3-20.31, Figure 4.3, sheet 13)

_____ Message Nr 2 says a 4 inch hole, 2 feet off the deck in compartment 3-90-2-L at FR 96, starboard side is being plugged/patched.

NAVEDTRA 43119- G	Topic	Task
318.2.9	Coordinate Repair Party efforts to combat/control fire.	Say steps of procedure

Question. List the steps the Repair Party Leader would take in fighting a fire in his/her area of responsibility.

Answer. (Reference NSTM 555-5.3.2)

1. _____ Determine the location of the fire.
2. _____ Determine the class of the fire.
3. _____ Determine the hazards the fire poses to adjacent spaces.
4. _____ Order fire boundaries.

5. _____ Order electrical isolation.
6. _____ Order mechanical isolation.
7. _____ Order smoke boundaries.
8. _____ Attack the fire.

NAVEDTRA 43119- G	Topic	Task
318.2.13	Coordinate Repair Party efforts to combat/control structural damage.	Say reasons for step

Question. List the reports or indications the Repair Party Leader might get that would cause him to believe shoring is required.

Answer. (Reference NSTM 079V2, 079-44.125)

1. _____ Deep bulges in plating.
2. _____ Bowed/bent frames.
3. _____ Bowed/bent stanchions.
4. _____ Cracked seams.
5. _____ Panting bulkhead.

Question. The Scene Leader is responsible for deciding whether to have the firefighters wear the FireFighter's Ensemble. You have a new scene leader who asks you whether his teams should wear the FFE. What factors should you consider in your response?

Answer. (Reference NSTM 555-5.2.1)

1. _____ Reduced endurance due to heat stress.
2. _____ Size of the fire (i.e. are the FFE's necessary for a small fire?).
3. _____ Progress of the fire while the fireparty is dressing out (i.e. is the fire likely to spread if the fireparty is delayed?)

NAVEDTRA 43119- G	Topic	Task
318.2.13	Coordinate Repair Party efforts to combat/control structural damage.	Say reasons for step

Question. Why is a panting bulkhead a dangerous condition?

Answer. (Reference NSTM 079V2, 079-44.125)

_____ Panting is a dangerous condition as it causes metal fatigue which in time will result in cracking or splitting.

Question. What does this message tell you as Repair Party Leader? (Show Message Blank Nr 3)

Answer. (Reference NWP 3-20.31, Figure 4.3, sheet 7)
_____ Message Nr 3 says Progressive flooding reported in compartment 2-406-1-Q, 4" deep

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NAVEDTRA 43119- G	Topic	Task
318.2.9	Coordinate Repair Party efforts to combat/control fire.	Say steps of procedure

Question. What are your methods of communication from the Repair Locker to other stations?

Answer. (Reference NWP3-20.31, Section 4.1)
1. _____ Sound-powered phones
2. _____ Ship's Service Telephones
3. _____ Intercom (i.e. 4MC)
4. _____ DC WIFCOM
5. _____ Messengers

Question. Your scene leader calls back to the Locker and reports that he needs 3 OBA relief personnel. You look around the Repair Locker area and there are no extra personnel available. What action do you take to help out the scene leader?

Answer. _____ Call DC Central and ask the DCA to find and send additional personnel.

Question. What does this message tell you as Repair Party Leader? (Show Message Blank Nr 4)

Answer. (Reference NWP 3-20.31, Figure 4.3, sheet 1)
_____ Message Nr 4 says fire boundaries have been set, primary forward FR 200, primary aft FR 245, secondary forward FR175, secondary aft FR 270.

Question. When might stability of the ship be considered a problem?

Answer. (Reference NWP 3-20.31, Art 5.3.5)
1. _____ Small or negative metacentric height with a logy, long period roll
2. _____ The extent of flooding exceeds floodable length
3. _____ Excessive list
4. _____ Heavy winds and seas combined with existing flooding

APPENDIX D. DATA SETS

This appendix contains the data sets used for this study. To simplify the analysis, integer indicators were assigned to some of the variables. Table 9 lists the variable and the applicable integer indicator employed. In order to incorporate education and rank

Variable	Integer Indicator
Class Convening Date (Mar 17, 1997)	1
Class Convening Date (April 14, 1997)	2
Class Convening Date (May 12, 1997)	3
Control Group	0
Treatment Group	1
Male	1
Female	0
Enlisted Surface Warfare (ESWS) Qualified	1
Not ESWS Qualified	0

Table 9. Assignment of Integer Indicators.

into the analysis, integers indicators had to be developed for those two variables. In the case of education, the DMDC database already had values associated with particular levels of education (Table 10). Table 11 provides the indicators assigned to the rank/rate variable.

Education Variable	Integer Indicator
3-4 Years High School (No diploma)	5
High School Diploma	6
2 Years of College	8
College Graduate	10
Masters or Equivalent	11
High School GED	13

Table 10. Education Variable Integer Indicators.

In the data set, E-5 represents second class petty officers. These subjects can be identified as being those whose rate designator ends with "2" (e.g. AT2). First class petty officers are those whose rate designator ends with "1" (e.g. HT1). E-7 represents a Chief Petty Officer (e.g. SKC), while W-2 corresponds with warrant officers (e.g. CWO2).

Among commissioned officers, O-1 and O-2 represent Ensign (ENS) and Lieutenant (junior grade) (LTJG), while O-3 and above corresponds with Lieutenants and senior.

Rank/Rate Variable	Integer Indicator
E-5	1
E-6	2
E-7 through W-4	3
O-1 through O-2	4
O-3 and above	5

Table 11. Rank/Rate Variable Integer Indicators

Table 12 provides the complete data covering all three classes that participated in the study between March and May 1997. The variable "Sea Time" refers to the amount

Class Date	Subject Nr	Group	Rank/ Rate	Education	ESWS	Gender	SeaTime (mo)	PreTest	ExpTime (min)	OBS1
3/17/97	1	Treatment	AT2	6	N	F	19	66.67	91	38.78
3/17/97	2	Treatment	AO1	6	Y	M	64	70.00	6	44.90
3/17/97	3	Treatment	DC2	6	Y	M	31	76.67	6	44.90
3/17/97	4	Treatment	SMC	6	Y	M	120	80.00	6	67.35
3/17/97	5	Treatment	ENC	6	Y	M	94	46.67	7	59.18
3/17/97	6	Treatment	ENS	10	N	M	7	73.33	36	53.06
3/17/97	7	Treatment	LT	10	N	M	43	73.33	3	65.31
3/17/97	8	Treatment	ENS	10	N	M	12	70.00	22	57.14
3/17/97	9	Treatment	ENS	10	N	F	8	73.33	32	40.82
3/17/97	10	Treatment	ENS	10	N	F	0	70.00	34	59.18
3/17/97	11	Treatment	CWO3	10	N	M	52	50.00	179	55.10
3/17/97	12	Treatment	LTJG	10	N	M	37	80.00	17	28.57
3/17/97	13	Control	DM1	6	N	M	50	23.33	0	22.45
3/17/97	14	Control	LCDR	11	N	F	1	60.00	0	46.94
3/17/97	15	Control	RMC	6	N	M	75	46.67	0	61.22
3/17/97	16	Control	CWO3	6	Y	M	173	76.67	0	61.22
3/17/97	17	Control	BM2	6	Y	M	120	63.33	0	22.45
3/17/97	18	Control	SKC	8	Y	F	51	46.67	0	40.82
3/17/97	19	Control	MMC	6	Y	M	111	66.67	0	59.18
3/17/97	20	Control	HT1	6	N	M	63	80.00	0	63.27
3/17/97	21	Control	LTJG	10	N	M	8	73.33	0	38.78
3/17/97	22	Control	ENS	10	N	M	6	63.33	0	48.98
3/17/97	23	Control	LTJG	10	N	M	17	70.00	0	44.90
4/14/97	24	Treatment	GSM2	6	Y	M	52	90.00	46	57.14
4/14/97	25	Treatment	EM1	6	N	M	97	73.33	22	48.98
4/14/97	26	Treatment	HT1	6	N	M	75	70.00	20	53.06
4/14/97	27	Treatment	GSE2	6	N	M	61	60.00	42	51.02

Class Date	Subject Nr	Group	Rank/ Rate	Education	ESWS	Gender	SeaTime (mo)	PreTest	ExpTime (min)	OBS1
4/14/97	28	Treatment	DC1	13	N	M	92	73.33	108	44.90
4/14/97	29	Treatment	ENC	5	Y	M	96	70.00	6	22.45
4/14/97	30	Treatment	CTRC	6	N	M	55	56.67	46	51.02
4/14/97	31	Treatment	RMC	6	N	F	0	70.00	6	57.14
4/14/97	32	Treatment	ENS	10	N	F	0	56.67	16	44.90
4/14/97	33	Treatment	LTJG	10	N	M	11	90.00	34	51.02
4/14/97	34	Treatment	ENS	10	N	M	12	66.67	10	46.94
4/14/97	35	Treatment	IC1	6	Y	M	72	60.00	16	65.31
4/14/97	36	Control	DC1	6	N	M	64	76.67	0	51.02
4/14/97	37	Control	HT1	13	N	M	48	46.67	0	38.78
4/14/97	38	Control	CWO3	6	N	M	162	80.00	0	61.22
4/14/97	39	Control	ENS	10	N	M	21	73.33	0	63.27
4/14/97	40	Control	MMC	6	Y	M	96	73.33	0	79.59
4/14/97	41	Control	MM1	6	N	M	31	76.67	0	36.73
4/14/97	42	Control	HT2	8	N	F	29	80.00	0	63.27
4/14/97	43	Control	HTC	6	N	M	108	76.67	0	53.06
4/14/97	44	Control	PNC	6	N	F	36	50.00	0	51.02
4/14/97	45	Control	PR1	13	N	M	47	70.00	0	40.82
4/14/97	46	Control	EMC	6	N	M	66	66.67	0	57.14
4/14/97	47	Control	IC1	6	Y	M	105	76.67	0	53.06
5/12/97	48	Treatment	ENS	10	N	M	0	60.00	12	79.59
5/12/97	49	Treatment	DC2	6	Y	M	29	70.00	24	93.88
5/12/97	50	Treatment	DC1	13	Y	M	38	76.67	22	93.88
5/12/97	51	Treatment	PNC	6	Y	M	60	70.00	48	77.55
5/12/97	52	Treatment	ENS	10	N	M	0	60.00	26	81.63
5/12/97	53	Treatment	LTJG	10	N	M	25	76.67	12	69.39
5/12/97	54	Treatment	ENS	10	N	M	2	66.67	14	71.43
5/12/97	55	Treatment	GSM1	6	Y	M	102	70.00	48	93.88
5/12/97	56	Treatment	SH1	6	Y	M	77	56.67	12	75.51
5/12/97	57	Treatment	LTJG	10	N	M	24	76.67	26	75.51
5/12/97	58	Treatment	ENS	10	Y	F	0	66.67	12	69.39
5/12/97	59	Treatment	LT	10	N	F	31	60.00	10	77.55
5/12/97	60	Treatment	LT	10	Y	M	18	43.33	20	81.63
5/12/97	61	Control	EN2	6	N	M	44	60.00	0	38.78
5/12/97	62	Control	LTJG	10	Y	M	11	66.67	0	51.02
5/12/97	63	Control	ENS	10	N	M	6	86.67	0	65.31
5/12/97	64	Control	DC1	6	Y	M	97	73.33	0	34.69
5/12/97	65	Control	LTJG	10	N	M	25	70.00	0	48.98
5/12/97	66	Control	DC1	13	Y	M	101	63.33	0	40.82
5/12/97	67	Control	LTJG	10	N	M	25	80.00	0	55.10
5/12/97	68	Control	LTJG	10	N	M	25	73.33	0	36.73
5/12/97	69	Control	SKC	6	N	M	34	63.33	0	38.78
5/12/97	70	Control	HT1	6	N	F	36	60.00	0	42.86
5/12/97	71	Control	BMC	6	Y	M	96	40.00	0	32.65
5/12/97	72	Control	LTJG	10	N	M	26	73.33	0	44.90
5/12/97	73	Control	ENS	10	N	M	10	70.00	0	55.10

Table 12. Complete Data Set.

of sea time the subject had accumulated (in months) up to the date the Repair Party Leader School class commenced. The PreTest column provides the score earned by the subject on the pretest administered the first day of the course. Exposure time is the amount of time (in minutes) the subject spent actually working scenarios on the IDCTT (RPL) computer. This was calculated by taking the difference between scenario start time and finish time for each scenario run by the members of the treatment group. Start and finish times are automatically recorded by the system and are stored on the computer's hard drive. The column labeled "OBS1" provides the score the subject earned on the post-treatment oral board conducted during the second week of the course.

Table 13 provides data used for analysis of the May 97 class alone.

Class Date	Subject Nr	Group	Rank/ Rate	Education	ESWS	Gender	SeaTime (mo)	PreTest	ExpTime (min)	OBS1
5/12/97	48	Treatment	ENS	10	0	1	0	60.00	12	79.59
5/12/97	49	Treatment	DC2	6	1	1	29	70.00	24	93.88
5/12/97	50	Treatment	DC1	13	1	1	38	76.67	22	93.88
5/12/97	51	Treatment	PNC	6	1	1	60	70.00	48	77.55
5/12/97	52	Treatment	ENS	10	0	1	0	60.00	26	81.63
5/12/97	53	Treatment	LTJG	10	0	1	25	76.67	12	69.39
5/12/97	54	Treatment	ENS	10	0	1	2	66.67	14	71.43
5/12/97	55	Treatment	GSM1	6	1	1	102	70.00	48	93.88
5/12/97	56	Treatment	SH1	6	1	1	77	56.67	12	75.51
5/12/97	57	Treatment	LTJG	10	0	1	24	76.67	26	75.51
5/12/97	58	Treatment	ENS	10	0	0	0	66.67	12	69.39
5/12/97	59	Treatment	LT	10	0	0	31	60.00	10	77.55
5/12/97	60	Treatment	LT	10	0	1	18	43.33	20	81.63
5/12/97	61	Control	EN2	6	0	1	44	60.00	0	38.78
5/12/97	62	Control	LTJG	10	0	1	11	66.67	0	51.02
5/12/97	63	Control	ENS	10	0	1	6	86.67	0	65.31
5/12/97	64	Control	DC1	6	1	1	97	73.33	0	34.69
5/12/97	65	Control	LTJG	10	0	1	25	70.00	0	48.98
5/12/97	66	Control	DC1	13	1	1	101	63.33	0	40.82
5/12/97	67	Control	LTJG	10	0	1	25	80.00	0	55.10
5/12/97	68	Control	LTJG	10	0	1	25	73.33	0	36.73
5/12/97	69	Control	SKC	6	0	1	34	63.33	0	38.78
5/12/97	70	Control	HT1	6	0	0	36	60.00	0	42.86
5/12/97	71	Control	BMC	6	1	1	96	40.00	0	32.65
5/12/97	72	Control	LTJG	10	0	1	26	73.33	0	44.90
5/12/97	73	Control	ENS	10	0	1	10	70.00	0	55.10

Table 13. May 1997 Data Set.

Table 14 provides the censored data set. As mentioned in Chapter IV.B.1, additional information was available for 52 of the 73 students participating in the study. The censored data set provided as Table 14 indicates the information available for these subjects. The data is listed by subject number; all information listed in Table 12 is the same. In the race category, 1 signifies white, 2 is black and 3 is other. The AFQT column

Subject Nr	Race	AFQT	Mental Cat	SAR	SPC	SCS	CAI
1	1	93	1	64	53	53	56.67
2	2	42	3.5	47	61	51	53.00
3	3	51	3	47	44	52	47.67
4	1	62	3	58	52	45	51.67
5	2	59	3	61	56	38	51.67
6	1	98	1	64	61	65	63.33
7	1	69	2	55	59	57	57.00
10	3	84	2	62	47	71	60.00
11	1	58	3	61	57	38	52.00
12	3	66	2	58	59	46	54.33
13	2	33	3.5	57	38	43	46.00
14	1	78	2	62	55	58	58.33
16	1	67	2	54	37	43	44.67
18	2	51	3	52	51	70	57.67
19	1	78	2	61	56	57	58.00
20	1	39	3.5	56	51	41	49.33
21	3	94	1	59	62	53	58.00
24	1	81	2	62	59	46	55.67
25	1	75	2	62	59	44	55.00
26	2	50	3	52	51	68	57.00
27	1	44	3.5	51	53	49	51.00
28	1	59	3	53	51	45	49.67
29	3	64	3	61	53	60	58.00
30	1	75	2	62	60	50	57.33
31	1	33	3.5	45	50	44	46.33
35	2	47	3.5	57	49	61	55.67
36	1	56	3	55	56	42	51.00
37	3	17	4.33	50	42	42	44.67
39	1	83	2	63	61	46	56.67
40	1	87	2	64	55	61	60.00
41	1	94	1	65	54	69	62.67
42	1	78	2	59	56	58	57.67
43	1	54	3	56	55	42	51.00
44	1	45	3.5	48	50	49	49.00
45	1	63	3	57	54	46	52.33
46	1	98	1	51	63	64	59.33
47	1	86	2	66	64	45	58.33
49	1	84	2	61	62	68	63.67

Subject Nr	Race	AFQT	Mental Cat	SAR	SPC	SCS	CAI
50	1	71	2	58	59	57	58.00
51	1	54	3	56	55	42	51.00
55	1	64	3	54	58	53	55.00
56	3	44	3.5	56	50	54	53.33
57	1	94	1	63	61	70	64.67
61	3	36	3.5	47	42	46	45.00
63	1	92	2	62	54	56	57.33
64	1	74	2	54	54	65	57.67
65	1	79	2	59	51	65	58.33
66	2	35	3.5	51	50	45	48.67
67	1	96	1	64	56	53	57.67
69	2	67	2	54	56	48	52.67
70	1	76	2	64	56	48	56.00
71	1	41	3.5	69	45	54	56.00

Table 14. Censored Data Set.

provides the percentile score achieved by the subject on the Armed Forces Qualification Test taken at the time of entry into the service. The Mental Category assigned to the individual is based on the AFQT percentile, as indicated in Table 15. SAR, SPC, SCS and CAI are as described in Chapter IV.B.2. The "S" indicates that the scores used were standardized by DMDC to account for variations between examinations.

AFQT Score	Mental Category	Integer Indicator
1 to 9	V	5
10 to 15	IV(c)	4.66
16 to 20	IV(b)	4.33
21 to 30	IV(a)	4
31 to 49	III(b)	3.5
50 to 64	III(a)	3
65 to 92	II	2
93 to 99	I	1

Table 15. AFQT Scores and Associated Mental Categories.

APPENDIX E. STEPWISE REGRESSION RESULTS

Stepwise regression was the primary tool used to aid in the selection of variables for this model. Further information regarding this technique is available in various books, including the reference listed in Chapter V.A. S-Plus was used to conduct the stepwise regression, and the results of this process is provided in this appendix. Table 16 provides the results for the complete data set, while Tables 17 and 18 refer to the May 1997 and Censored data sets, respectively.

rss:									
	16480.2	14053.89	13784.41	13516.54	12878.84	12842.31	12811.78	12803.99	12803.33
size:									
	1	2	3	4	5	6	7	8	9
which:									
	Class	Group	Rank	Education	ESWS	Gender	SeaTime	PreTest	ExpTime
1(+2)	F	T	F	F	F	F	F	F	F
2(+1)	T	T	F	F	F	F	F	F	F
3(+8)	T	T	F	F	F	F	F	T	F
4(+3)	T	T	T	F	F	F	F	T	F
5(+5)	T	T	T	F	T	F	F	T	F
6(+4)	T	T	T	T	T	F	F	T	F
7(+9)	T	T	T	T	T	F	F	T	T
8(+7)	T	T	T	T	T	F	T	T	T
9(+6)	T	T	T	T	T	T	T	T	T
f.stat:									
	11.91957	12.08505	1.348916	1.347617	3.317538	0.187727	0.154911	0.038944	0.003217

Table 16. Stepwise Regression Results (Complete data set).

rss									
	2029.515	1672.756	1529.69	1410.136	1174.59	1134.164	1122.389	1122.327	
size									
		1	2	3	4	5	6	7	8
which									
	Class	Group	Rank	Education	ESWS	Gender	SeaTime	PreTest	ExpTime
1(+2)	F	T	F	F	F	F	F	F	F
2(+8)	F	T	F	F	F	F	F	T	F
3(+9)	F	T	F	F	F	F	F	T	T
4(+7)	F	T	F	F	F	F	T	T	T
5(+5)	F	T	F	F	T	F	T	T	T
6(+4)	F	T	F	T	T	F	T	T	T
7(+3)	F	T	T	T	T	F	T	T	T
8(+6)	F	T	T	T	T	T	T	T	T
f.stat									
		94.20182	4.905348	2.057581	1.780417	4.010695	0.677225	0.188848	0.000935

Table 17. Stepwise Regression Results (May 1997 data set).

Stepwise Selection by Censored Method (Forward, Intercept Only)													
rss													
	11994.8	10161.1	9137.1	8063.15	7814.19	7651.95	7552.57	7367.97	7338.68	7302.41	7272.24	7271.56	
size													
	1	2	3	4	5	6	7	8	9	10	11	12	13
which													
	Class	Group	Rank	Education	Race	AFQT	MenCat	CAI	ESWS	Gender	SeaTime	PreTest	ExpTime
1(+5)	F	F	F	F	T	F	F	F	F	F	F	F	F
2(+2)	F	T	F	F	T	F	F	F	F	F	F	F	F
3(+9)	F	T	F	F	T	F	F	F	T	F	F	F	F
4(+1)	T	T	F	F	T	F	F	F	T	F	F	F	F
5(+12)	T	T	F	F	T	F	F	F	T	F	F	T	F
6(+11)	T	T	F	F	T	F	F	F	T	F	T	T	F
7(+3)	T	T	T	F	T	F	F	F	T	F	T	T	F
8(+7)	T	T	T	F	T	F	T	F	T	F	T	T	F
9(+6)	T	T	T	F	T	T	T	F	T	F	T	T	F
10(+13)	T	T	T	F	T	T	T	F	T	F	T	T	T
11(+4)	T	T	T	T	T	T	T	F	T	F	T	T	T
12(+8)	T	T	T	T	T	T	T	T	T	F	T	T	T
13(+10)	T	T	T	T	T	T	T	T	T	T	T	T	T
f.stat													
	7.70503	8.8426	5.3799	3.2870	2.7195	1.4337	0.9329	0.5658	1.0523	0.1636	0.1987	0.1618	0.0035

Table 18. Stepwise Regression Results (Censored data set).

APPENDIX F. RESULTS OF ANOVA

Analysis of variance (ANOVA) was used to refine the model suggested by stepwise regression. Table 19 is the output provided by S-Plus for the complete data set. As stated in Chapter V.A.3, the stepwise regression identified five variables to be

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
Group	1	2766.718	2766.718	23.62394	0.0000176
Class	1	2426.314	2426.314	20.71736	0.0000468
PreTest	1	269.479	269.479	2.30097	0.1369662
Rank	1	267.87	267.87	2.28723	0.1381127
ESWS	1	637.702	637.702	5.44509	0.024607
Group:Class	1	3067.522	3067.522	26.19239	0.0000077
Group:PreTest	1	901.118	901.118	7.6943	0.008301
Class:PreTest	1	29.886	29.886	0.25518	0.6161537
Group:Rank	1	39.352	39.352	0.33601	0.565311
Class:Rank	1	252.927	252.927	2.15964	0.1493099
PreTest:Rank	1	143.189	143.189	1.22263	0.2752905
Group:ESWS	1	226.284	226.284	1.93215	0.1720248
Class:ESWS	1	1.019	1.019	0.0087	0.9261202
PreTest:ESWS	1	103.144	103.144	0.88071	0.3535037
Rank:ESWS	1	69.546	69.546	0.59383	0.4453605
Group:Class:PreTest	1	5.656	5.656	0.04829	0.8271532
Group:Class:Rank	1	355.76	355.76	3.0377	0.0888477
Group:PreTest:Rank	1	37.679	37.679	0.32172	0.5736663
Class:PreTest:Rank	1	35.669	35.669	0.30456	0.5840326
Group:Class:ESWS	1	0.651	0.651	0.00556	0.9409365
Group:PreTest:ESWS	1	1.356	1.356	0.01158	0.9148351
Class:PreTest:ESWS	1	18.757	18.757	0.16016	0.6910846
Group:Rank:ESWS	1	1408.606	1408.606	12.02754	0.0012454
Class:Rank:ESWS	1	151.548	151.548	1.29401	0.2619146
PreTest:Rank:ESWS	1	235.005	235.005	2.00662	0.1641676
Group:Class:PreTest:Rank	1	570.478	570.478	4.87109	0.0329664
Group:Class:PreTest:ESWS	1	0.015	0.015	0.00013	0.9910162
Group:Class:Rank:ESWS	1	180.19	180.19	1.53857	0.2218821
Group:PreTest:Rank:ESWS	1	3.152	3.152	0.02691	0.8704972
Class:PreTest:Rank:ESWS	1	238.532	238.532	2.03673	0.161111
Group:Class:PreTest:Rank:ESWS	1	0.084	0.084	0.00071	0.9788252
Residuals	41	4801.716	117.115		

Table 19. Analysis of Variance (Complete data set).

considered for inclusion in the model. This ANOVA was based on those variables and considered all interactions.

Table 20 provides the output for ANOVA of the May 1997 data set. Stepwise regression identified six variables in this case. Again, interactions were considered by the model.

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
Group	1	7966	7966	180.7974	0.000889
PreTest	1	356.759	356.759	8.097	0.065349
ExpTime	1	143.066	143.066	3.2471	0.169348
SeaTime	1	119.554	119.554	2.7134	0.198064
ESWS	1	235.546	235.546	5.346	0.103828
Education	1	40.426	40.426	0.9175	0.408795
Group:PreTest	1	182.365	182.365	4.139	0.134765
PreTest:ExpTime	1	25.097	25.097	0.5696	0.505256
Group:SeaTime	1	248.67	248.67	5.6438	0.098
PreTest:SeaTime	1	2.804	2.804	0.0636	0.817117
ExpTime:SeaTime	1	29.16	29.16	0.6618	0.475486
Group:ESWS	1	0.012	0.012	0.0003	0.987719
PreTest:ESWS	1	106.72	106.72	2.4221	0.217492
ExpTime:ESWS	1	125.069	125.069	2.8386	0.190614
SeaTime:ESWS	1	64.645	64.645	1.4672	0.312501
Group:Education	1	16.942	16.942	0.3845	0.579115
PreTest:Education	1	28.688	28.688	0.6511	0.478758
SeaTime:Education	1	38.076	38.076	0.8642	0.421143
ESWS:Education	1	9.022	9.022	0.2048	0.681617
Group:PreTest:SeaTime	1	79.741	79.741	1.8098	0.271182
PreTest:ExpTime:SeaTime	1	41.012	41.012	0.9308	0.405822
Group:PreTest:ESWS	1	3.96	3.96	0.0899	0.783916
Residuals	3	132.181	44.06		

Table 20. Analysis of Variance (May 1997 data set).

Table 21 provides the results of ANOVA for the censored data set. Stepwise regression identified six variables, and these were further examined by ANOVA.

	Df	Sum of Sq	Mean Sq	F Value	Pr(F)
Race	1	1848.419	1848.419	22.67897	0.0010264
Group	1	1833.695	1833.695	22.4983	0.0010541

ESWS	1	1024.092	1024.092	12.56498	0.0062676
Class	1	597.253	597.253	7.32792	0.0241151
Pre.TestScore	1	476.693	476.693	5.84873	0.0387111
Rank	1	227.722	227.722	2.79401	0.128951
Race:Group	1	108.059	108.059	1.32581	0.2792213
Race:ESWS	1	131.198	131.198	1.60972	0.2363613
Group:ESWS	1	829.158	829.158	10.17326	0.0110144
Race:Class	1	213.854	213.854	2.62385	0.1397207
Group:Class	1	1253.432	1253.432	15.37884	0.0035025
ESWS:Class	1	12.227	12.227	0.15002	0.7075132
Race:Pre.TestScore	1	163.938	163.938	2.01142	0.1898031
Group:Pre.TestScore	1	825.495	825.495	10.12831	0.0111399
ESWS:Pre.TestScore	1	22.057	22.057	0.27063	0.6154652
Class:Pre.TestScore	1	53.86	53.86	0.66083	0.437242
Race:Rank	1	570.646	570.646	7.00147	0.0266491
Group:Rank	1	4.797	4.797	0.05885	0.8137546
ESWS:Rank	1	250.14	250.14	3.06906	0.1137081
Class:Rank	1	10.245	10.245	0.1257	0.7310961
Pre.TestScore:Rank	1	46.447	46.447	0.56988	0.4696002
Race:Group:ESWS	1	452.659	452.659	5.55384	0.0428352
Race:Group:Class	1	1.258	1.258	0.01543	0.9038705
Race:ESWS:Class	1	4.092	4.092	0.05021	0.8277026
Group:ESWS:Class	1	208.327	208.327	2.55605	0.1443372
Race:Group:Pre.TestScore	1	315.862	315.862	3.87543	0.0805217
Race:ESWS:Pre.TestScore	1	35.505	35.505	0.43563	0.5257699
Group:ESWS:Pre.TestScore	1	18.538	18.538	0.22745	0.644788
Race:Class:Pre.TestScore	1	179.472	179.472	2.20201	0.1719847
Group:Class:Pre.TestScore	1	15.524	15.524	0.19047	0.6728119
ESWS:Class:Pre.TestScore	1	12.792	12.792	0.15695	0.7012067
Race:Group:Rank	1	79.774	79.774	0.97878	0.34835
Race:ESWS:Rank	1	109.023	109.023	1.33764	0.2772258
Group:ESWS:Rank	1	455.537	455.537	5.58916	0.0423133
Race:Class:Rank	1	61.968	61.968	0.76032	0.40589
Group:Class:Rank	1	201.166	201.166	2.46818	0.1506208
ESWS:Class:Rank	1	0.262	0.262	0.00322	0.9560002
Race:Pre.TestScore:Rank	1	79.74	79.74	0.97836	0.3484488
Group:Pre.TestScore:Rank	1	147.054	147.054	1.80426	0.2120857
ESWS:Pre.TestScore:Rank	1	208.93	208.93	2.56345	0.143824
Class:Pre.TestScore:Rank	1	9.872	9.872	0.12112	0.7358237
Group:Class:Pre.TestScore:Rank	1	8.991	8.991	0.11031	0.7473905
Residuals	9	733.533	81.504		

Table 21. Analysis of Variance (Censored data set).

APPENDIX G. POWER FUNCTION GENERATION

This appendix provides the S-Plus function that was used to develop the power function curves shown in Chapter V. As shown, this function requires six input values and provides a graphical output.

```
> FindPower
function(mean.delta, x, y, data.1, data.2, LvlofSig)
{
# mean.delta is the vector of mean values for which the user wants to calculate the power
of the test (i.e. mean.delta_seq(-20,20,0.01)
# x is sample variance of treatment group
# y is sample variance of control group
# data.1 is treatment group data set dependent variable, a vector
# data.2 is control group data set dependent variable, a vector
# LvlofSig is the desired level of statistical significance
        alpha <- 1 - LvlofSig
        for(i in 1:length(mean.delta)) {
                if(mean.delta[i] > 0) {
                        z[i] <- qnorm(alpha) - (mean.delta[i])/(x/length(data.1) + y/
                                length(data.2))^0.5
                }
                else if(mean.delta[i] < 0) {
                        z[i] <- qnorm(alpha) + (mean.delta[i])/(x/length(data.1) + y/
                                length(data.2))^0.5
                }
                else if(mean.delta[i] == 0) {
                        z[i] <- qnorm(alpha) - (mean.delta[i])/(x/length(data.1) + y/
                                length(data.2))^0.5
                }
                t <- pnorm(z)
        }
        win.graph()
        plot(mean.delta, 1 - t, type = "l", main = "Power Function for Data", ylab =
                "Power", xlab = "Difference between Data Means")
}
```

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